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Economic Significance of the Florida Phosphate Industry

An Input-Output (I-O) Analysis

By Anthony M. Opyrchal and Kung-Lee Wang

UNITED STATES DEPARTMENT OF THE INTERIOR

United States. Bureau of Mines.

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UNITED STATES DEPARTMENT OF THE INTERIOR
James G. Watt, Secretary

BUREAU OF MINES

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

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PREFACE

This Information Circular, prepared by the Bureau of Mines' Branch of Economic Analysis, updates the previous Information Circular, "Economic Significance of the Florida Phosphate Industry" (IC 8653, 1974). It presents recent information on the economic impact of the Florida phosphate industry and discusses new areas of economic analysis such as forward linkage economic impact and fiscal impact analysis. Also employed in this report are standard tools of economic analysis, including industrial complex analysis, location quotient theory, and—most importantly—input-output techniques with related multiplier analyses.

Included as appendix D is a hypothetical scenario based on the assumption that the future impact of Florida's phosphate rock industry will decline. In this scenario, the effects of certain anticipated restraints upon Florida's phosphate rock mining industry are examined.

The authors would like to thank William F. Stowasser, phosphate commodity specialist, Bureau of Mines, Washington, D.C., for technical and editorial assistance in the preparation of this publication.

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ECONOMIC SIGNIFICANCE OF THE FLORIDA PHOSPHATE INDUSTRY

An Input-Output (I-O) Analysis

by

Anthony M. Opyrchal[1] and Kung-Lee Wang[2]

ABSTRACT

This Bureau of Mines study assesses the economic significance of the Florida phosphate industry to selected counties in Florida, the State of Florida, and the Nation; it also includes a brief survey of the industry's international impact. Based on forecasts of Florida phosphate production in 1981, and using constant 1977 dollars, estimates are given for 1981 for regional and national output, the value of this output, income, and employment created by the phosphate industry in Florida. Federal, State, and county tax revenues generated by the State's phosphate industry are also estimated for 1981. The concentrated impact of the phosphate industry on certain areas of Florida and on the State's regional industries is examined using economic base analysis complimented by an industrial complex approach. The industry's impact at the State and national levels is examined through input-output analysis.

In addition, an attempt to forecast for 1990 the effects of constraints on phosphate rock mining as a result of economic conditions and other factors is included as an appendix to the report. Also discussed is the phosphate industry's importance to the U.S. balance of trade; U.S. agricultural production, including forward linkages; the U.S. sulfur industry; and the phosphate industry's importance to the production of fluorine and uranium byproducts from fertilizer manufacturing.

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INTRODUCTION

The United States in recent years has accounted for more than 40 percent of the worldwide production of phosphate rock. U.S. production has been sufficient to meet domestic demand while also allowing considerable exports; only minor quantities of phosphate products have been imported in recent years. The U.S. phosphate rock industry is concentrated in three areas—Florida and North Carolina; Tennessee; and the western States of Idaho, Montana, Utah, and Wyoming. Of the total U.S. phosphate production in 1977 and 1978, about 80 percent was from Florida deposits; this means that Florida's phosphate production represented about one-third of world total.

The bulk of Florida's phosphate production is from two central Florida countries, Polk and Hillsborough. However, several recent developments could possibly result in curtailed future levels of phosphate rock production from these two counties. These developments are related to changing economic conditions, environmental considerations, and other factors. A detailed discussion of a scenario that encompasses these developments is given in appendix D for the year 1990.

The Bureau of Mines undertook this study of the Florida phosphate industry as part of its effort to maintain an adequate supply of minerals to meet national economic and strategic needs. The study illustrates the economic significance of the Florida phosphate industry to the phosphate-producing regions of Florida, the State of Florida as a whole, and the Nation, and also gives a brief survey of the industry's international impact. An estimate of the industry's impact in these areas for a 1-year period (1981) further underscores the importance of phosphate rock production in the State of Florida.

This report also provides information on various other aspects of the Florida phosphate industry. Economic base studies are described which were conducted on the two principal phosphate-producing regions within Florida in an effort to quantify direct and indirect employment and income impacts of the industry on these small regional economies. An industrial complex approach employing input-output (I-O) analysis is also used to determine the interrelationships between the Florida phosphate industry and various other related industries on a statewide basis. Among the interrelationships determined in this manner are the regional impacts of the State's phosphate industry on shipping and other transportation, electric utilities, and State tax collections (including property taxes paid to counties). The effects of phosphate industry activities are estimated for 1981 with respect to output, employment levels, and personal income on a statewide basis.

The national significance of the Florida phosphate industry is subsequently described in terms of supply and demand. (Factors relevant to changing production levels are discussed in appendix D.) Also discussed are the effects of the Florida phosphate industry on the U.S. balance of payments, the U.S. sulfur industry, and byproduct uranium and fluorine production from phosphate fertilizer processing.

The vital importance of phosphate fertilizer to the agricultural sector of the U.S. economy is examined, and the impact of the domestic phosphate industry on world consumption of phosphate fertilizers is described. Finally, world phosphate rock production and its capacity for this production are related to future prospects for the Florida phosphate industry. Specific conclusions are given at the end of the report.

The data presented in this report were collected to serve as a basis for analysis. In many instances the data are not the most recent available. Nonetheless, they are useful for demonstrating the various analytical approaches that are discussed, and the data and analyses together provide a viable profile of the Florida phosphate industry.

Terminology

An understanding of the terms used in this report is crucial to the various discussions that follow. Therefore, generalized definitions are given below for some of the basic terms used throughout the report. Other important terms are subsequently defined in the body of the report.

The phosphate industry refers to the whole scope of that industry's operations, from rock mining and beneficiation through production of finished fertilizers. *Phosphate rock* refers to the marketable product after the mined matrix, containing pebble and concentrates, waste and tailings, and waste colloidal clay particles (slimes), is beneficiated. Phosphate rock generally refers to any material containing one or more phosphate minerals, usually calcium phosphate. For commercial purposes, the term *marketable phosphate rock* is applied to the product of a deposit of sufficient quantity and purity that it can be used, either directly or after concentration, in the manufacturing of commercial phosphate products.

Central Florida phosphate rock is made up of phosphatized limestone, sands, and clay, as well as phosphate pebbles. Phosphate pebbles are referred to as either *land pebble* or *river pebble* depending on the location of the deposit.

The counties that currently produce significant quantities of phosphate in central Florida are Polk and Hillsborough Counties, but the *central Florida phosphate district* circumscribes phosphate deposits over an area of roughly 2,000 square miles which also includes Manatee, Hardee, and DeSoto Counties. The term *central Florida phosphate district* is used in this report to refer to the entire resource area, while the term *central Florida region* is used to refer to the two currently producing counties, Polk and Hillsborough. (A small amount of the production attributed to the central Florida region is mined in Hardee County from the southern extension of a deposit located primarily in Polk County.)

The production of phosphate also takes place in Hamilton County, although most of the producer's employees live in Columbia County. These two counties in northern Florida are referred to as the *northern Florida region*. Phosphate industry employment in Hamilton County represented more than 10 percent of Florida's total phosphate industry employment in 1977.

Other terms commonly used in this report are defined below.

Economic base theory (analysis)—the study of cities and regions using basic-service ratios, that is, the ratio of employment (total or change in total) in basic activities to employment in nonbasic activities; the study of regional multipliers.

Exports—the sale or transfer of goods and services outside the country.

Florida Phosphate Council—an organization consisting of phosphate producers in the State of Florida.

Imports—the sale or transfer of goods and services into the country.

Input-output (I-O) analysis—the study of the general interdependence of regional, interregional, and national economies.

Interregional transfers in—the sale or transfer of goods and services into a region.
Interregional transfers out—the sale or transfer of goods and services out of a region.
Location quotient—an analytical device used for comparing a region's percentage share of a particular activity with its percentage share of some basic aggregate such as income or employment.
Phosphate industrial complex—all companies involved in phosphate industry activities in the State of Florida.

Historical Background

Land-pebble phosphate deposits were discovered in central Florida in 1877 in an area known as the Bone Valley Formation. This area is about 50 miles long and 40 miles wide; it includes parts of Hillsborough, Polk, and Hardee Counties (fig. 1) and is approximately 25 miles east of Tampa. The deposits found in this area occur as sedimentary beds of phosphate pebbles, sand, and clay. Similar deposits were later discovered in Hamilton County, west of Jacksonville.

Early phosphate mining in central Florida was from river-pebble deposits. Production was quite low, amounting to only 2,720 metric tons in 1888. As demand for fertilizer increased, mining quickly shifted to the land-pebble deposits. The first significant mining of these deposits began in 1890. By 1892, production had increased to 275,000 metric tons. By 1900 phosphate production in the central Florida district had increased to more than 680,000 metric tons per year. Production has continued to rise to more than 3.3 million metric tons in 1930, 12.5 million metric tons in 1960, and nearly 36 million metric tons in 1975. In 1978 phosphate rock production in central Florida totaled about 40 million metric tons.

Northern Florida land-pebble mining began in 1965 in Hamilton County and currently accounts for about 10 percent of the State's total production.

Since the first mining of land-pebble deposits in central Florida in 1880, the Florida phosphate industry has experienced many technological imorovements that have permitted

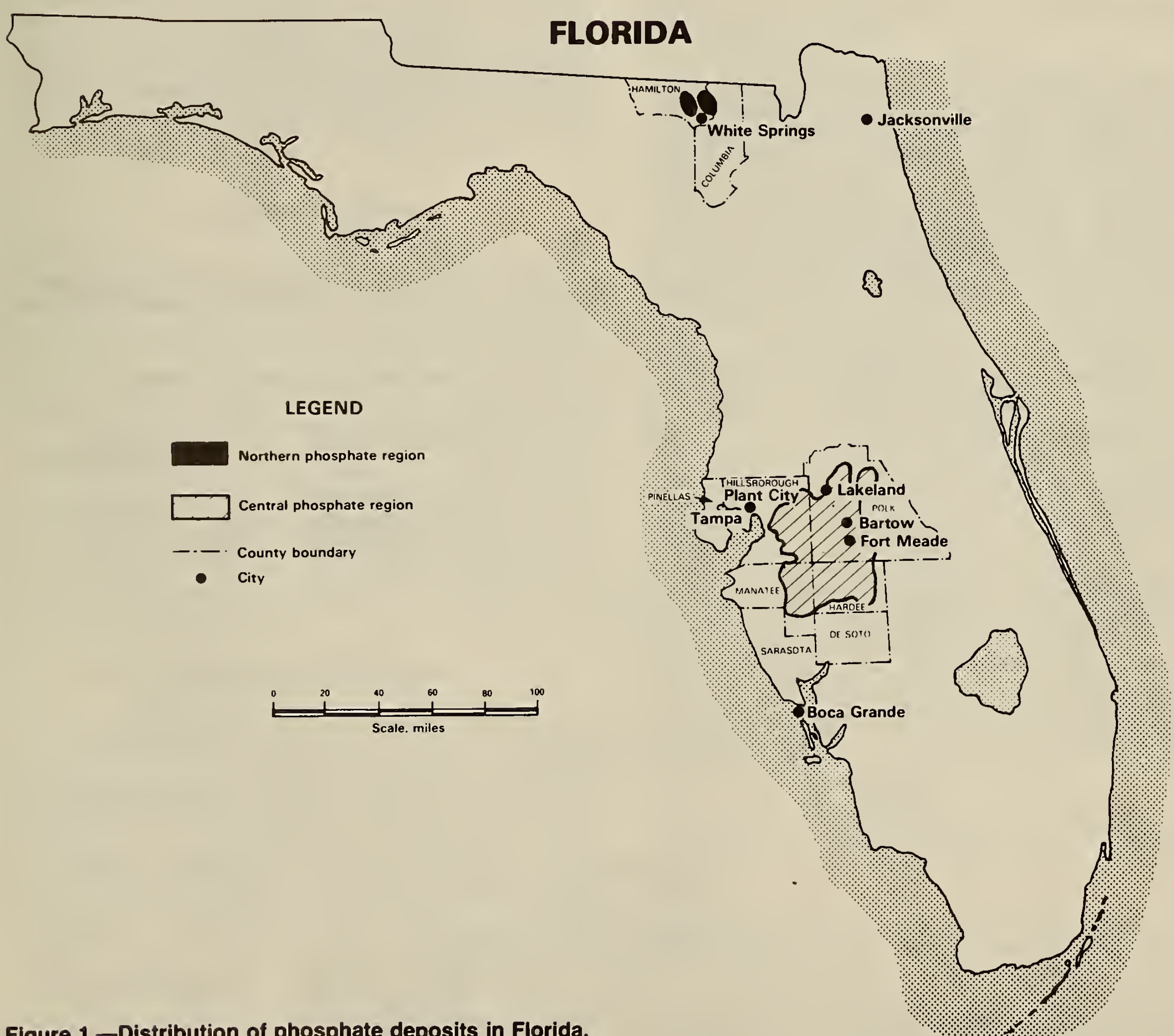


Figure 1.—Distribution of phosphate deposits in Florida.

greater recovery from existing deposits. Examples of these improvements are the introduction of electrically driven draglines to mine the overburden and matrix; the use of high-pressure water guns to provide a slurry for the new dredge-type pumps; and, most importantly, the introduction of flotation for recovering fine material that was previously discarded after washing.

During the last 30 years, the U.S. phosphate industry has characteristically had a relatively small number of producers because of the profitability of large-scale operations and the geographical concentration of deposits. During the 1950's, 10 major phosphate rock companies in the United States accounted for 80 percent of the total U.S. production. In the 1960's, these 10 major companies produced more than 85 percent of the U.S. total. In the 1970's, 15 companies mined over 95 percent of the Nation's phosphate rock. Although ownership of some of the major companies has changed over the past several decades, the same 10 to 15 firms still produce most of the phosphate rock in the United States.

Nature and Structure of the Present Industry

In their early years, Florida's phosphate operations were, for the most part, mining operations. Today, the industry is an integrated complex of mining, beneficiation, fertilizer manufacturing, and other chemical production. This new industry structure emerged in the 1960's, a period of rapid expansion during which many fertilizer, oil, and chemical firms were merged to form integrated companies, as shown in table 1.

By the late 1960's, the marketing patterns of the phosphate industry in Florida were comprised of domestic shipments of dry phosphate rock to the upper Gulf Coast, with sulfur shipments returned to Florida; shipments of dry phosphate rock along the Atlantic seaboard; and exports of dry phosphate rock. This pattern changed slightly in the early 1970's as several new chemical fertilizer plants were built on the Gulf Coast and lower Mississippi River in closer proximity to sulfur deposits and lower cost natural gas. Wet phosphate rock is barged to these areas and dried prior to processing.

Products of the phosphate industry can be classified as fertilizers, detergents, animal feeds, food products, and "other." The "other" category includes mainly specialized fertilizer materials. Most companies involved in phosphate fertilizer production have operations that are involved in every step of the production chain. Of the 12 companies involved in phosphate mining in Florida in 1977, 10 were also involved in beneficiation of the ore as well as processing phosphate chemicals. This reflects the degree of vertical integration in the Florida phosphate industry.

Of the companies listed in table 1, only Mobil Chemical Co. and Brewster Phosphate Co. are not currently processing phosphate chemicals. T. A. Minerals Corp., (which is not listed in the table) also is not currently processing phosphate chemicals. Brewster and T. A. Minerals are both small phosphate recovery operations with soft-rock mines. Companies that are producing phosphate chemicals but are not involved in mining and beneficiation are C. F. Industries, Converse, Inc., Electro-Phos Corp., Farmland Industries, and Royster Co.

Mining Procedure

Current Florida production (1978) of phosphate rock takes place in Polk and Hillsborough Counties in the central Florida

Table 1.—Chronology of major acquisitions and entries into the phosphate rock industry, 1950–77[1]

1950 American Agricultural Chemical Corp.		1963 Acquired by Continental Oil Co.	1972 Acquired by Williams Co.	1977 Agrico Chemical Co. (Division of the Williams Co.)
American Cyanamid Co.			1972 Brewster Phosphate Co. formed (joint venture of American Cyanamid Co. and Kerr-McGee Corp.)	Brewster Phosphate Co. (joint venture of American Cyanamid Co. and Kerr-McGee Corp.)
Cornet Phosphate Co.	1952 Acquired by Smith-Douglas	1964 Acquired by Borden Chemical Co.		Borden Chemical Co.
Davidson Chemical Corp.	1954 Acquired by W.R. Grace and Co.			W.R. Grace & Co.
International Minerals & Chemical Corp.				International Minerals & Chemical Corp.
Swift & Co.				Swift Chemical Co.
Virginia-Carolina Chemical Corp.		1963 Acquired by Socony Mobil Co.		Mobil Chemical Co.
	1955 Armour Fertilizer Co. (Initiated phosphate rock production)	1968 Acquired by U.S. Steel Corp.		U.S.S. Agri-Chemicals, Inc. (owned by U.S. Steel Corp.)
		1965 Occidental Oil Co. (initiated phospate rock production)		Occidental Agricultural Chemical Co.
		1966 Texasgulf Corp. (initiated phosphate rock production)		Texasgulf, Inc.
		1967 Cities Service Corp. (initiated phosphate rock production)	1973 Acquired by Societe des Participation Gardinier	Societe des Participation Gardinier.

[1] This table does not include Tennessee and Western States producers; two small recovery operations and soft-rock mines are also excluded.
Source: Florida Phosphate Council (*32*).

region, with Hardee County also contributing a small amount. Production in the northern Florida region takes place in Hamilton County. There is also additional mining potential in DeSoto and Manatee Counties.

The mining procedures used in the Florida land-pebble phosphate field is to strip the overburden and mine the phosphate matrix with a dragline. As cuts are made by the dragline, overburden is placed on adjacent mined-out areas, and the matrix is stacked in a sluice pit prepared on unmined ground. The matrix is then mixed with water under high pressure to produce a slurry, and the slurry is pumped to a washing plant for beneficiation. A typical 3-million-ton-per-year operation annually mines about 400 acres of land, removing 13 million cubic yards of overburden and producing 9 million cubic yards of matrix. Mined-out areas are used for disposal of tailings, slime ponds, and redistribution of overburden. Approximately 1 ton of sand tailings and 1 ton of phosphate clay must be disposed for each ton of marketable phosphate rock produced. Overburden and sand tailings are used to construct holding dams in mined-out areas, where phosphatic clay slimes are impounded to settle and dewater.

Water is used in the beneficiation process and as a transportation medium. Both freshwater from deep wells and reclaimed water from sand tailings and slime-settling ponds are used. It is estimated that the production of 1 ton of marketable phosphate rock requires 10,000 gallons of water, but about 85 percent of this water is reclaimed and recycled.

Beneficiation

Methods of phosphate beneficiation differ only slightly as a function of the size analysis of the feed; the ratio of washer rock to flotation feed; and the proportions of sand, clay, and phosphate in the matrix. The matrix is broken down by a series of screens in closed circuit with hammermills and logwashers to separate the clay and sand from the phosphate pebbles. The washer produces phosphatic clay slimes and a sized flotation feed and recovers a pebble product.

Concentrates are floated from the minus 14- plus 150-mesh fraction. The waste or tailings from the flotation process are used in both holding dam construction and land reclamation. The marketable phosphate rock obtained through beneficiation is sold as a final product or used captively as a raw material to produce a variety of chemical products.

Chemical Processes

After beneficiation, phosphate rock still contains from 7 to 20 percent moisture. Although some processes use phosphate rock wet-ground at these moisture levels, phosphate rock commonly sold in domestic and export markets contains less than 3 percent moisture. Drying the rock facilitates shipping in below-freezing temperatures and also reduces freight costs by reducing the weight. Rock drying is required to produce triple superphosphate (TSP), or if the rock is to be shipped to a wet-process phosphoric acid plant that cannot accept wet-ground rock. Phosphate rock dryers are mostly fueled by natural gas, but can also use oil as a standby fuel. If the rock contains a high percentage of organic material, it must be calcined at temperatures higher than those normally required for drying.

A wide variety of agricultural and industrial chemicals is produced by Florida's phosphate processing operations. This production requires large quantities of elemental sulfur and anhydrous ammonia, which are imported or brought in from other States. Elemental sulfur is the primary raw material used in the production of sulfuric acid, which in turns is used to produce wet-process phosphoric acid and normal superphosphate. the ammonia is reacted with phosphoric acid at varying degrees of neutralization to produce different grades of ammonium phosphates.

Phosphoric acid is produced from sulfuric acid and phosphate rock. It is used to manufacture ammonium phosphates as well as TSP. TSP is a high-analysis product made by reacting phosphoric acid with dry phosphate rock. It is used as a direct-application nutrient in farming and in the manufacture of high-analysis-grade fertilizer.

An important group of chemical products produced by the Florida phosphate industry is the ammonium phosphate group. Grades produced in Florida from wet-process phosphoric acid are labeled 18–46–0, or modified diammonium phosphate (DAP), and 13–52–0, or primary monoammonium phosphate (MAP). The three numbers indicate respectively, the percentages of total nitrogen, available phosphate as P_2O_5, and soluble potash as K_2O.

Normal superphosphate, which contains between 16 and 20 percent available phosphate, is produced by reacting sulfuric acid with phosphate rock. After curing, normal superphosphate is disintegrated for commercial use both in direct application and with other plant nutrients in the production of mixed fertilizers. With the rising demand for higher analysis fertilizers, however, both the demand for and production of normal superphosphate have declined.

Super phosphoric acid, which is used as a phosphate intermediate, is a concentrated phosphoric acid produced from either the wet process or from furnace orthophosphoric acid. Water is evaporated to produce the super acid. Elemental phosphorus is produced by smelting phosphate rock with coke and quartz in electric furnaces. This smelting operation also produces ferrophosphorus, carbon monoxide, and calcium silicate. About 50 percent of the elemental phosphorus produced is used to produce sodium phosphate detergents.

Also produced from phosphate rock are animal-feed-grade phosphates. Phosphate rock is used to produce low-fluorine mineral supplements for livestock and poultry feed. Defluorination, which is necessary because fluorine is toxic to animals, is accomplished by adding defluorinating agents such as phosphoric acid and soda compounds in controlled amounts to phosphate rock and calcining the mixture at high temperatures. Defluorinated phosphoric acid is reacted with lime to produce dicalcium phosphates.

Fluorine and its related products are byproducts of the Florida phosphate industry. One of these, hydrofluosilicic acid, is used to treat drinking water and is also converted into a synthetic cryolite.

Current Supply and Demand for Phosphate Products

The elements of supply and demand for the U.S. phosphate industry during 1977 and 1978 are shown in table 2. Figure 2 is a detailed flowsheet of U.S. demand for 1977. In recent years the United States has furnished more than 40 percent of the world's supply of phosphate rock, and most of the U.S. production has come from Florida. The United States is self-sufficient in phosphorus and imports less than 1 million tons

Table 2.—Phosphate rock and coproducts supply and demand quantities, 1977–78

(Thousand metric tons and percent)

	1977		1978	
	Tonnage	Share	Tonnage	Share
World production:				
United States	47,256	40.8	50,037	40.0
Rest of world	68,692	59.2	74,963	60.0
Total	115,948	100.0	125,000	100.0
U.S. supply components:				
Domestic mines	47,256	77.2	50,037	77.3
Imports	158	.3	908	1.4
Industry stocks, Jan. 1	13,777	22.5	13,818	21.3
Total U.S. supply	61,191	100.0	64,763	100.0
Distribution of U.S. supply:				
Industry stocks, Dec. 31	13,818	22.6	15,081	23.3
Exports[1]	13,230	21.6	12,870	19.9
U.S. demand	34,365	56.2	36,812	56.8
Apparent supply deficit[2]	−222	−.4	0	0
Total	61,191	100.0	64,763	100.0
U.S. demand components:				
Fertilizer	30,262	88.1	31,958	86.8
Detergents	1,760	5.1	2,185	5.9
Animal feeds	601	1.8	700	1.9
Food products	285	.8	368	1.0
Other	1,457	4.2	1,601	4.4
Total U.S. primary demand	34,365	100.0	36,812	100.0

[1] Exports reported by companies to the Bureau of Mines.
[2] Difference between distribution of U.S. supply and total U.S. supply.

per year. The historical trend in phosphorus applications and demand has been stable, but there are some indications that there is a shift towards exporting higher value processed phosphate products rather than untreated phosphate rock.

In 1977 the largest domestic end use of phosphate products was for agriculture, which accounted for 88 percent of U.S. consumption. The chief agricultural product was intermediate phosphoric aid, which comprised 79 percent of the total demand for phosphate rock in 1977. Phosphoric acid was used to produce diammonium phosphate, triple superphosphate, and, after defluorination, dicalcium phosphate. Only 11.9 percent of U.S. phosphate consumption went to industrial applications, and nearly all of this consumption was as elemental phosphorus. About 5 percent of the industrial consumption was used in making detergents. Elemental phosphorus was also used to produce furnace phosphoric acid, from which a variety of sodium, calcium, and potassium phosphates were manufactured.

Environmental Considerations

Environmental problems associated with the phosphate industry include concerns about excessive water consumption and power demands, the effects of radiation, water and air quality, and the adequacy of land reclamation programs. In a recent Bureau contract report (*38*),[3] an attempt was made to quantify the environmental sensitivity of future phosphate resource development in Florida. The report identifies Florida's present and future phosphate resources and also identifies those phosphate resources which may be of special concern because of inadequate water supply, radiation, or the potential for wetlands disturbance. The report evaluates the phosphate resource potential of Florida on a deposit-by-deposit basis, identifying areas of land, water, vegetation, wildlife, etc. For each deposit, the report includes an evaluation of the overall environmental sensitivity to phosphate mining with respect to both shot- and long-term effects.

It is emphasized that this study is intended to outline the direct economic benefits of the Florida phosphate industry and is not intended to identify environmental costs. In this study, no estimates are made of the economic costs of the industry's current or potential environmental problems.

[3] Underlined numbers in parentheses refer to items in the Bibliography preceding the appendixes.

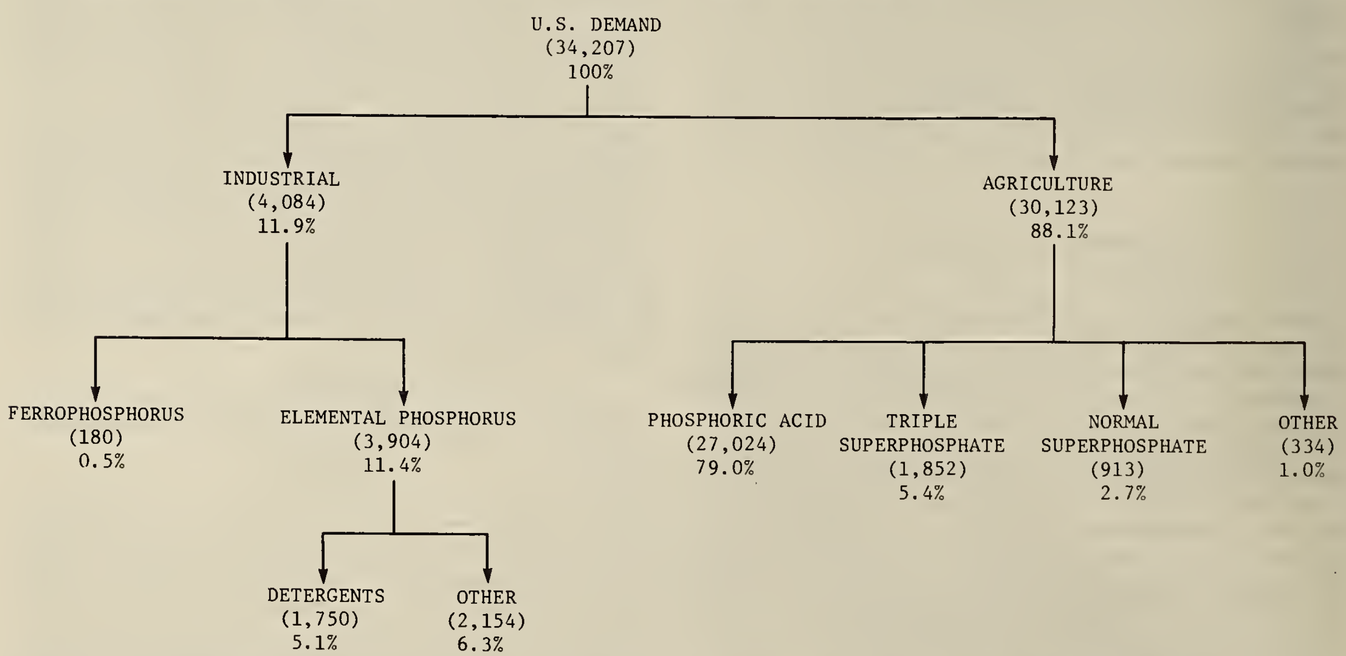


Figure 2.—Domestic marketable phosphate rock distribution pattern, 1977, in thousand metric tons.

ECONOMIC BASE STUDIES OF TWO FLORIDA REGIONS

This section seeks to quantify direct and indirect employment and income impacts of the Florida phosphate industry on two small regional economies. The localized regions of impact are identified, a survey of economic base theory is presented, and statistics generated by application of the theory to the phosphate industry are provided.

Identification of the Impact Regions

The Florida phosphate industry is concentrated in a relatively small geographical area. In 1978 phosphate rock was mined in only four Florida counties. Most of this mining was in Polk County in central Florida, and lesser amounts were mined in Hardee and Hillsborough Counties, also in central Florida, and Hamilton County in northern Florida. In 1978 Polk and Hillsborough Counties accounted for 90 percent of Florida's phosphate employment.

The primary objective of this economic base study was to identify as precisely as possible the regions in which the greatest expenditures attributable to the phosphate industry were made. Two Florida regions were so identified, the central Florida region, which includes Polk and Hillsborough Counties, and the northern Florida region, which includes Hamilton and Columbia Counties.

In the central Florida region, a preponderance of the local indirect income and expenditures flowing from phosphate industry employment in central Florida was generated within Polk and Hillsborough Counties, where most workers employed locally by the industry reside. Large metropolitan areas within these counties provide support goods and services to employees. The mining currently taking place in Hardee County is from a deposit in Polk County that extends over the county line, and most of the income from this mining remains in Polk County.

The situation in the northern Florida region is somewhat different. A large number of the mining and processing employees at the Hamilton County operation live in adjoining Columbia County. Therefore, the impact of the industry is spread across both counties. Both counties are predominantly agricultural; the phosphate industry is the only major industrial enterprise.

A second objective of this economic base study was to gage the impact of the Florida phosphate industry with respect to the entire State of Florida. Although the greatest impact is localized within the two phosphate regions, there are some ripple effects throughout the Florida economy. This is because the local goods and services suppliers in the two regions rely on other Florida counties and cities for some of their resources. The State of Florida itself can be viewed as a region and is treated as such in a subsequent section of this study.

Most of the phosphate rock and derivative products produced from Florida deposits is shipped to other States and to foreign nations. The two regions under analysis, central Florida and northern Florida, can be considered subregions of the United States in terms of this economic activity. Therefore, the economic impact variables used in this study utilize the rest of the United States as the base region to which these two subregions transfer goods and services. The phosphate industry does not transfer services, but the services are embodied in the goods.

The Economic Base Model

The intention of an economic base study is to provide the most accurate description possible of the sources and levels of income and employment in a region by identifying particular key economic activities. Such a study hypothesizes that the key economic activities of a region—those that direct and determine the development of the region—are the activities of the industries, firms, and individuals that serve markets *outside the region.* All other industries, firms, and individuals of the local economy are categorized as those which serve markets *within the region.* The theory is closely related to the theory of foreign trade impact on the domestic economy.

Goods and services sold outside the boundaries of a region are defined as interregional transfers out (ITO's). The remainder of goods and services goes to the local market, which is defined as all areas within the geographic region under analysis. The local market may include a State, a county, a city, or any other designated market area. In this economic base study, the local regions are the central Florida and the northern Florida region.

An *ITO industry* is an industry that produces an amount of output greater than that which can be consumed in the local market area. The *ITO market,* which is made up of ITO industries, is similar in concept to an export market, except that ITO's refer to transfers from one region in a country to another region *within the same country.* The extra output of the ITO market is transferred or sold outside the region or local market area.

Both the employment and income of the regions are affected by ITO markets, the driving force of local economies. Employment offering services to the ITO markets is termed *basic,* while employment serving the local market is considered *nonbasic.* Employment by an industry or a firm within an industry is often divided between the basic and nonbasic categories in an economic base analysis. Basic (ITO) employment plus nonbasic (local) employment, when summed for all industries, equals the total employment of the region.

The first step in identifying the impact of changes in the basic sector on the local economy is to allocate the units of measure (either employment or income) to the proper sectors. This can be accomplished by direct measurements through a comprehensive survey of all firms, but in actual practice, the survey procedure is almost always bypassed because of its prohibitive cost. A more widely accepted alternative is to measure the ITO industries indirectly, using location quotients. Employment is used as the unit of measure for most indirect measurement methods, but in this study both employment and income measures are used.

An explanation of location quotients and a concept similar to ITO employment appears in reference 16. Location quotients and multipliers have been estimated in terms of employment and income for each of the defined regions. The chief interest in this section is the direct and indirect employment and income effects of changes in output in the Florida phosphate industry.

Table 3.—Major specialized industries in Florida and average weekly wages, 1975

Industry	SIC[1]	Employment location quotient	Average weekly wage	
			Florida	United States
Building construction; general contractor and operative builders[2]	15	15.44	$202	$254
Lumber and other building materials dealers	521	13.08	174	193
Loan correspondents and brokers	616	8.89	235	246
Office of chiropractors	804	6.89	166	96
Chemical and fertilizer mineral mining	147	5.96	230	252
Miscellaneous apparel and accessory stores	569	5.84	115	104
Gum and wood chemicals	286	5.59	253	220
Agricultural services, except animal husbandry and horticultural services	071	5.30	171	148
Private employment agencies	736	4.58	91	120
Fruit, tree nut, and vegetable farms	012	3.72	192	165
Agricultural chemicals	287	3.66	241	206
Fishing, hunting, and trapping[2]	09	3.23	173	263
Commercial sports and miscellaneous amusement and recreational services[2]	794-799	3.12	133	128
Horticultural services	073	3.06	133	164
All industry	NAp	NAp	166	183

NAp Not applicable.
[1] Standard Industrial Classification.
[2] These SIC's are aggregated at higher than three-digit levels.
Source: Florida State University (study done under contract to the Bureau of Mines) (6).

Data Base Sources

Because of the availability of comprehensive data at the three-digit Standard Industrial Classification (SIC)[4] working level, employment and income data for 1975 were used for the economic base model estimates. The national data are from the Bureau of Labor Statistics (BLS), U.S. Department of Labor. The income figures are wage and salary estimates based on first-quarter 1975 data, and the employment figures are annualized averages. Florida employment and payroll data were provided by State government sources. The State wage and salary figures are those reported for the whole year. The obtained data provide a basis for comparability between SIC industries in the Nation, the State, and the counties, in most cases.

[4] A classification described in the Standard Industrial Classification Manual, 1972, published by the Executive Office of the President, Office of Management and Budget.

Location quotients for the central Florida and northern Florida regions were computed using the procedure described in reference 16. One set of quotients is based on employment data; the other is based on industry wages and salaries. Both types of quotients are derived from three-digit SIC industries, with some exceptions.

Table 3 shows the leading specialized industries in Florida, based on the location quotient method. Industries that had an employment location quotient greater than 3.00 and a minimum of 1,000 workers employed during the year are listed. (An employment location quotient greater than 3.00 generally identifies an industry that has strength and potential for further development within the region.) These basic industries, which serve markets outside Florida, include two

Table 4.—Employment in major specialized industries in countries of study area, 1975

Industry	SIC[1]	Employment location quotient			
		Polk	Hamilton	Hillsborough	Columbia
Chemical and fertilizer mineral mining	147	161.70	220.08[2]	3.83	NAp
Agricultural chemicals	287	35.69	225.80[2]	14.46	NAp
Agricultural services, except animal husbandry and horticultural services	071	26.54	NAp	4.24	NAp
Building construction; general contractor and operative builders	15	25.27	10.20	17.48	41.39
Lumber and other building materials dealers	521	24.00	10.24	8.50	NAp
Fruit, tree nut, and vegetable farms	012	14.55	NAp	2.84	NAp
Commercial sports and miscellaneous amusement and recreational services	794-799	7.57	7.04	12.66	5.06
Offices of chiropractors	804	6.49	8.87	6.77	NAp
Horticultural services	073	2.63	7.70	2.40	NAp
Miscellaneous apparel and accessory stores	569	2.02	NAp	6.95	NAp
Private employment agencies	736	1.93	NAp	9.95	NAp
Loan correspondents and brokers	616	1.11	NAp	5.09	NAp
Gum and wood chemicals	286	NAp	NAp	NAp	NAp
Fishing, hunting, and trapping[3]	09	NAp	NAp	4.39	NAp

NAp Not applicable.
[1] Standard Industrial Classification.
[2] Florida State University location quotients adjusted by the Bureau of Mines.
[3] These SIC's are aggregated at higher than three-digit levels.
Source: Florida State University (study done under contract to the Bureau of Mines) (6).

that are largely comprised of phosphate industry activities—chemical and fertilizer mineral mining (SIC 147) and agricultural chemicals (SIC 287). Chemical and fertilizer mineral mining ranks sixth among ITO industries in Florida, and agricultural chemicals processing ranks tenth.

This analysis leads to three major conclusions:

1. Phosphate rock mining and agricultural chemicals production are among Florida's leading ITO industries (as defined by location quotients).

2. In pure economic terms, the phosphate industry represents a growth leader for the State of Florida.

3. Without the phosphate industry, a major economic catalyst would be lost.

Average weekly wages and salaries for Florida's and the Nation's specialized industries are also reported in table 3. Average U.S. wages were about 10 percent higher than the Florida average; but for agricultural chemicals, which accounted for 41 percent of all 1976 phosphate industry employment in Florida, average wages were 17 percent higher in Florida than the nationwide average. However, the national wage differential in chemical and fertilizer mineral mining (SIC 147) was about equal to the Florida average difference. In 8 of the 14 leading Florida ITO industries, the national average wage was higher than the Florida average.

The major specialized industries in the study regions are listed for 1975 in table 4. Although Polk County has a diverse industrial base, chemical and fertilizer mineral mining (SIC 147), with a location quotient (LQ) of 161.70, is by far its leading ITO industry. Agricultural chemicals (SIC 287), with an LQ of 35.69, is the second leading basic industry in Polk County and also in Hillsborough County. However, chemical and fertilizer mineral mining is relatively insignificant in Hillsborough County.

In Hamilton County the leading ITO industries are chemical and fertilizer mineral mining, with an LQ of 220.08, and agricultural chemicals production, with an LQ of 225.80. Hamilton County's other industries include those that service the phosphate industry, and a few other industries such as building construction, lumber, and other building materials dealers. Neighboring Columbia County, like Hamilton County, is not significantly industrialized; building construction is its leading ITO industry. Even though Columbia County's economic activity is influenced by the phosphate industry in Hamilton County, there is no phosphate mining or agricultural chemical production in the county.

From table 4 it can be seen that the phosphate industry (SIC 147) leads Polk County's ITO industries in employment, even though the county has an otherwise diverse industrial base. In Hamilton County, however, it is the lack of industrial diversity that makes the phosphate industry the leading ITO employer.

Regional Impact Multipliers

Regional impact multipliers are the ratio of total income to basic income, or of change in total income to change in basic income. Employment is also used to estimate these multipliers. Regional impact multipliers are used to make projections of future levels of income and employment.

Regional impact multipliers were computed in conformity with the economic base theory described in reference 16. First, the location quotients were used to identify the basic (ITO) and nonbasic (local support) industries. Second, the total wages and salaries paid by each ITO industry were estimated. This procedure was repeated for each industry,

Table 5.—Wages and salaries and income multipliers for all Florida industries, 1975

	Central Florida	Northern Florida
Nonbasic wages and salaries...millions....	$1,893.8	$60.4
Basic income ....do....	$929.3	$37.5
Total wages and salaries ....do....	$2,823.1	$97.9
Regional income multiplier	[1]3.04	[1]2.61

[1] These income multipliers are based on location quotients calculated by Florida State University as part of a study done under contract to the Bureau of Mines (*6*).

Source: Various Florida State government agencies.

and the total wages and salaries of all industries—both ITO and local—were summed. The ratio of total regional income to ITO income was the *income multiplier*. The technique used to derive regional *employment multipliers* was the same. Such estimates can be made for any region for both types of multipliers; in this case, the selected regions were central and northern Florida. The multipliers used were the average multipliers for all the industries in the region, and not just those of the phosphate industry.

The location quotients in tables 3 and 4 show that the Florida phosphate industry was a major ITO industry in both regions in terms of both employment and income. Income multipliers for the two regions were derived by summing the total wages and salaries table 5 and determining the ratio of the regions' total wages and salaries to their ITO (basic) incomes for 1975, the most recent year for which income data were readily available. The resultant income multipliers were 3.04 for central Florida and 2.61 for northern Florida. These multipliers were averages for all industries in the study areas.

An industry's *direct impact* is the wages, salaries, and employment that it generates. Estimated payroll, or income, data for the Florida phosphate industry are given by region in table 6 for 1977. Nearly all of the total payroll of more than $153 million was divided equally between phosphate rock mining (SIC 1475) and phosphate fertilizer production (SIC 2874); a small amount also came from the production of industrial inorganic chemicals, including elemental phosphorus (SIC 2819). Less than 3 percent of this total payroll was earned outside the two study regions.

Each industry also has an indirect impact which stems from certain basic needs that are shared by all of the industry's employees. These needs include food, clothing, shelter, and other goods and services provided by the local support economy. In this study, *local support* for the primary industry is viewed as the industry's *indirect impact;* it is equal to the direct income (or employment) multiplied by the value of the income (or employment) multiplier, less the total direct income (or employment). Multiplying the regional phosphate industry wages and salaries (table 6) by the income multi-

Table 6.—Estimated regional wages and salaries[1] in Florida phosphate industries, 1977

(Millions)

	Central Florida	Northern Florida
Phosphate rock mining	$68.2	$7.6
Industrial chemicals	1.7	NAp
Phosphate fertilizers	67.9	8.0
Total	137.8	15.6

NAp Not applicable.

[1] Rounded to nearest thousand dollars.

Table 7.—Impact of the Florida phosphate industry on local regional wages and salaries, 1977[1]

(Millions)

	Central Florida	Northern Florida
Direct	$137.8	$15.6
Regional indirect	281.1	25.1
Total	418.9	40.7

[1] Based on Florida State Department of Commerce wage and employment data, Florida Phosphate Council employment data, and income multipliers calculated by Florida State University.

Table 9.—Distribution of employment within the Florida phosphate industry, 1977

	Central Florida[1]	Northern Florida[1]
Phosphate rock mining	5,300	585
Industrial chemicals	200	NAp
Phosphate fertilizers	5,100	615
Total	10,600	1,200

NAp Not applicable.
[1] Rounded numbers.
Source: State of Florida employment statistics, including unpublished data; and individual Florida phosphate companies.

pliers (table 5) shows that the phosphate industry generated a total direct and indirect impact of $418.9 million in central Florida and more than $40.7 million in northern Florida (table 7).

Employment multipliers for the two regions were determined by summing total employment in each region and computing the ratio of total employment to ITO (basic) employment (table 8). Although the income multipliers were determined using 1975 as a base year, the employment multipliers were determined using 1977 data. However, it is unlikely that the location quotients and multiplier ratios changed from 1975 to 1977, since the factors that determine the magnitude of these multipliers were not altered during this period.

The employment multipliers were 2.62 for the central Florida region and 2.17 for the northern Florida region. These multipliers corresponded with the ranking of the two regions' income multipliers, except that the employment multipliers were smaller than the income multipliers for each region. This was so because the national wage rates were higher, on the average, than Florida's wage rates, as shown in table 3.

Table 9 provides a breakdown of employment distribution for the phosphate industry in the two regions. The totals shown include any administrative personnel necessary for the operation of each subindustry. In terms of percentages, the subindustry employment totals correspond with the subindustry income totals presented in table 6.

Regional employment impacts of the Florida phosphate industry, both direct and indirect, are shown in table 10. Multiplying the direct employment (table 9) by the estimated multiplier (table 8) for each region equals total employment, which includes indirect employment. In the central Florida region, more than 27,000 jobs are directly or indirectly related to phosphate production; in the northern Florida region, phosphate-related jobs total more than 2,600.

As a measure of the importance of these total levels of phosphate industry wages and salaries and employment (direct plus indirect impacts), phosphate-related wages and salaries and employment were calculated as percentages of the total regional income and employment for the central and northern Florida regions. These percentages were calculated for 1975, using the data from tables 5 and 8 plus 1975 industry wage and salary data collected from the phosphate companies and Florida State government agencies. The calculations showed that in the central Florida region, where about 90 percent of the Florida phosphate industry is located, an estimated 13 percent of the region's total wages and salaries and 8 percent of its total employment were generated either directly or indirectly by the phosphate industry. In northern Florida, the respective percentages were approximately 40 and 21, reflecting the low level of industrialization in Columbia and Hamilton Counties. Percentage shares for succeeding years would likely be similar.

There are a number of possible reasons why the employment shares were smaller than those for wages and salaries. One factor was that the multipliers for wages and salaries were larger than the employment multipliers. This is because the phosphate industry is capital-intensive, with a relatively large ratio of capital investment to labor employment. And, as shown in table 3, the wage rates in the phosphate industry were well above the average wages for the State. (This average wage differential is also shown in table 24, in the section, "The Phosphate Industry: An Industrial Complex Approach.")

Table 8.—Employment and employment multipliers for all Florida industries, 1975

	Central Florida	Northen Florida
Nonbasic employment	189,067	6,433
Basic employment	115,520	5,490
Total employment	304,587	11,923
Regional employment multiplier	[1]2.62	[1]2.17

[1] These employment multipliers are based on location quotients calculated by Florida State University as part of a study done under contract to the Bureau of Mines (6).
Source: Various Florida State government agencies.

Summary

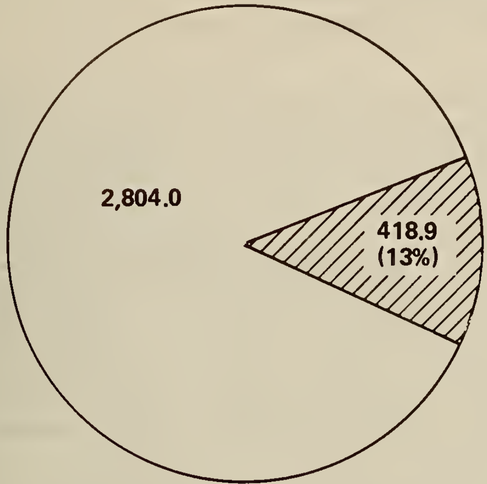
Two phosphate industry impact regions have been defined, the central Florida region, which includes Polk and Hillsborough Counties, and the northern Florida region, comprising Hamilton and Columbia Counties. In the northern Florida region, phosphate production takes place only in Hamilton County.

In these regions the phosphate industry is an ITO industry that generates income and employment for other local in-

Table 10.—Regional employment generated by the phosphate industry in Florida, 1977[1]

	Central Florida	Northern Florida
Direct	10,600	1,200
Regional indirect	17,172	1,404
Total	27,772	2,604

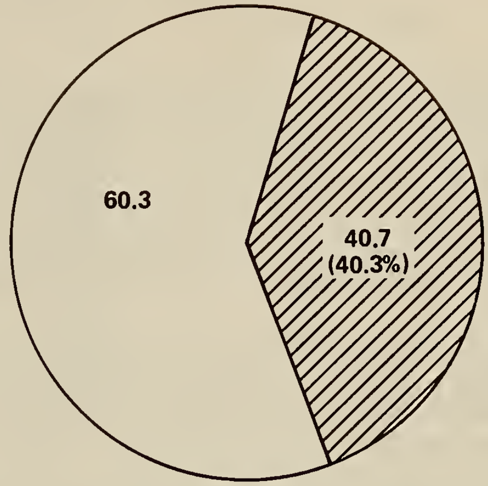
[1] Based on employment multipliers calculated by Florida State University.
Sources: Florida State Department of Commerce and individual phosphate companies.



WAGES AND SALARIES BREAKDOWN:

PHOSPHATE INDUSTRY	418.9
ALL OTHER INDUSTRIES	2,804.0
TOTAL WAGES AND SALARIES	3,222.9

Figure 3.—Total wages and salaries attributable to the phosphate industry in central Florida in 1977 (million dollars).



WAGES AND SALARIES BREAKDOWN:

PHOSPHATE INDUSTRY	40.7
ALL OTHER INDUSTRIES	60.3
TOTAL WAGES AND SALARIES	101.0

Figure 4.—Total wages and salaries attributable to the phosphate industry in northern Florida in 1977 (million dollars).

dustries. The economic base model demonstrates this; comparison of the estimated location quotients shows phosphate chemical and fertilizer mining and agricultural chemicals production to be the leading ITO industries in Polk and Hamilton Counties and agricultural chemicals production to be the second leading ITO industry in Hillsborough County. The phosphate industry in Hamilton County, although small as a percentage of statewide production, dominates the industrial sector of that county owing to the county's otherwise insignificant industrial base.

Through the use of regional multipliers it was possible to estimate the direct and indirect impacts of the Florida phosphate industry on both regions. Total 1977 wages and salaries of approximately $418.9 million were attributed to the phosphate industry in central Florida. In northern Florida, approximately $40.7 million in wages and salaries was generated by the phosphate industry. These industry totals represented an estimated 13 and 40 percent, respectively, of the two regions' total wages and salaries, as shown in figures 3 and 4. The industry's regional employment shares were smaller, but nonetheless significant. Some 8 percent of the regional employment in central Florida and 21.4 percent of northern Florida's regional employment was linked to the phosphate industry.

THE PHOSPHATE INDUSTRY: AN INDUSTRIAL COMPLEX APPROACH

Location quotient theory and economic base analysis, common techniques used in developing regional studies such as those in the preceding section, have some limitations in addition to their many positive attributes. One limitation is that these techniques may overlook certain interrelationships, such as the possibility of interaction between regions. Therefore, an interregional input-output (I-O) approach was also used to study the Florida phosphate industry as an industrial complex.

Of the general interdependence approaches available, the interregional I-O approach is most prominent in terms of accomplishment and recognition. I-O analysis (also known as interindustry analysis) is a general technique that points up the complex interdependence of diverse business, consumer, political, and other cultural units of society. It uncovers to a significant degree the intricate structure of an economy, providing a fertile forum for the display and scrutiny of the underlying factors and processes that bind together the economically multifaceted regions of the economic system. The strength of I-O analysis lies in its comprehensive representation of (1) the production and distribution characteristics of individual industries of different regions and (2) the interrelationships among these industries and between these industries and other economic sectors. It expresses, in essence, the basic fabric of an interindustry system as it exists not only within each region but also among regions.

A more specific approach, the industrial complex technique, can be integrated into general interdependence I-O analysis. An *industrial complex* may be defined as a set of activities occurring at a given location and belonging to a group (subsystem) of activities that are subject to important production, marketing, or other interrelationships.

Most of the activities relevant to this analysis of the phosphate industrial complex in Florida take place in the central Florida region, which includes the Tampa Bay area. A much smaller level of activity, which is nonetheless important to the complex, takes place in the northern Florida region and the Port of Jacksonville. Along with the estimated economic impacts that can be identified as direct results of the phosphate industry, other impacts can be approximated through the use of I-O analysis techniques.

I-O analysis is used to study the interdependence of economic sectors. I-O models have been developed for the study of national as well as regional and State economies. For the analytical framework used in this report, a State I-O model was developed that permits measurement of the economic activity in the State of Florida with special emphasis on the phosphate industry. A Bureau of Mines I-O table of the Florida economy (*17*) was used to estimate phosphate industry multipliers. This table included data compiled for 1972 for 338 industrial sectors such as those listed in tables 3 and 4 of this report.

The assumptions embodied in the analytical framework are briefly reviewed here, and a detailed methodology that describes this framework is included in appendix A. First, an estimate of the Florida phosphate industry's annual production of major products was determined for 1981. From these estimates, the phosphate industry's employment, income, and value of output were estimated for 1981, using 1977 dollars and assuming constant wages and productivity. Regional multipliers were then applied to the employment and income estimates to determine the industry's total economic impact, including direct, indirect, and induced effects (*19*). (*Induced effects* refers to the repercussionary effects of secondary rounds of spending or employment.) Multipliers were also applied to the value-of-output estimates in order to determine the direct and indirect effects of the industry's output, which together represent the industry's total statewide output value.

The result is a projection of the phosphate industry as it might exist in 1981, based on growth rates estimated by the Bureau. In addition to the Florida phosphate industry's effects on that State's economy, the output, employment, and income effects of the Florida industry on the national economy were also identified. A national I-O model for 1972, which included data for 404 industrial sectors (*28*), was used for this purpose.

The importance of the Florida phosphate industrial complex lies mainly in its backward and forward linkages. *Backward linkages* in the phosphate industry are those purchases of inputs by the phosphate industrial complex, such as purchases of goods and services, that are associated with the production of phosphate rock and derivative products. These purchases consist chiefly of basic materials and minerals; machinery, supplies, and parts; and labor resources. In this analysis, fiscal aspects of the industrial complex are also considered as part of the backward linkages. There is a significant amount of leakage from the State in terms of inputs necessary to run the complex. What this means is that a part of the inputs are purchased outside the limits of the industrial complex (meaning in this case outside the State of Florida).

Forward linkages of the phosphate industrial complex are sales of intermediate products, in most cases to other industries. These include sales of phosphate rock, agricultural chemicals, and industrial chemicals. Most of the industry's phosphate rock sales is for the domestic market outside Florida, and the remainder is exported to foreign nations. Agricultural phosphate chemicals are sold mainly for use as fertilizers or as intermediates for processing into mixed fertilizers, and small amounts are also sold as animal feed supplements. A small part of the sales of the Florida phosphate industrial complex is in the form of elemental phosphorus, which is used in detergents formulation, pharmaceuticals, and many other products. Most of the State's elemental phosphorus that is used to produce industrial chemicals is marketed outside Florida.

The Regional Impact

Shipments of phosphate products through the Port of Tampa in 1976 (table 11) accounted for 87 percent of the tonnage and 80 percent of the value of all phosphate product exports from the State of Florida. (These percentages were derived from data aggregated from country-by-country tabulations listed under Code Number 18[5] of the U.S. Bureau of the Census, and a portion of these aggregated data is shown in table 11.) The Port of Jacksonville accounted for 6.7 percent of the tonnage and 5.6 percent of the value of the State's phosphate product exports, and the Port of Boca Grande handled 3.3

[5] Code Number 18, a classification that includes virtually all Florida ports, is used by the U.S. Department of Commerce, Bureau of the Census, in the compilation of foreign trade statistics.

Table 11.—Exports of phosphate products[1] from Tampa

(Metric tons and dollars)

Product	1976 Quantity	1976 Value	1977 Quantity	1977 Value
Florida phosphate rock and Florida land pebbles	8,315,876	281,279,207	12,228,868	316,450,764
Diammonium phosphate	1,519,183	180,940,373	1,814,001	233,005,751
Concentrated superphosphate	979,999	91,129,080	957,926	90,837,793
Phosphoric acid, fertilizer grade	221,549	51,821,356	295,504	66,449,100
Ammonium phosphate fertilizers	76,752	9,335,077	139,113	16,379,997
Mixed chemical fertilizers, n.e.c.	7,669	1,004,212	23,418	2,530,261
Phosphatic chemical fertilizers, n.e.c.	9,290	1,395,700	13,426	2,004,361
Normal chemical enriched superphosphate	0	0	34,803	862,281
Natural phosphate fertilizers	109,225	2,357,827	37,126	840,321
Elemental phosphorus	230	324,865	332	420,652
Dicalcium phosphate	36	7,296	2,196	338,172
Phosphoric acid, n.e.c.	0	0	98	3,072
Total	11,239,809	619,594,993	15,546,811	730,122,525

[1] Includes products listed under Code Number 18 of the Bureau of the Census.
Source: U.S. Department of Commerce, Bureau of the Census, foreign trade statistics.

percent of the total tonnage and 7 percent of these exports in terms of value. Other Florida ports that exported phosphate products—although in relatively low volumes in terms of both tonnage and value—were Fernandina Beach, St. Petersburg, and Port Canaveral.

The Florida Phosphate Council has estimated that the Florida phosphate industry's expenditures for water transportation in 1977 amounted to $21.3 million, or 4 percent of the total value of the products shipped. These outlays were divided among barge and ocean traffic.

In the next three subsections of this report, the effects of the phosphate industrial complex on Polk County are summarized; and the import-export and domestic shipping activities are discussed, together with employment data, for the Ports of Tampa, Jacksonville, and Boca Grande.

POLK COUNTY

A large share of the activity of the Florida phosphate industrial complex is centered in Polk County. In 1977, total employment in Polk County was greater than 98,000, and of this total, more than 8,600 workers were employed by the phosphate industry. These 8,600 employees earned more than $110 million in 1977.[6] The economic significance of the phosphate industry's work force has been shown to be much larger than is suggested by the industry's nominal 9 percent share of employment in Polk County. The phosphate industry has historically contributed property taxes equal to about 30 percent of the total amount collected in Polk County. The tax base of the county government and the viability of the local economy both depend heavily on the phosphate industry.

THE PORT OF TAMPA[7]

The Port of Tampa, which includes all deepwater facilities within the city of Tampa, is one of the 10 largest ports in the United States in terms of tonnage volume. In 1977 it handled more than 46 million metric tons of cargo, and of this tonnage, 61 percent was products either sold or purchased by the Florida phosphate industrial complex (table 12). Phosphate

[6] Florida Department of Labor and Employment Security, Division of Employment Security.
[7] See reference map in figure 1.

Table 12.—Inbound and outbound traffic through the Port of Tampa for selected commodities related to the phosphate industries, 1977

(Metric tons)

Commodities	Total	Foreign		Domestic		Barge shipments	
		Imports	Exports	Inbound	Outbound	In	Out
Ammonia	157,655	157,655	0	0	0	0	0
Ammonium sulfate	23,847	0	0	0	0	23,847	0
Fertilizer, bagged	9,135	0	7,629	0	0	0	1,507
Fertilizer, materials	41,400	21,083	18	0	0	20,299	0
Phosphate, bagged	2,971	0	2,971	0	0	0	0
Phosphate, bulk	18,032,144	0	10,814,815	0	165,618	0	7,051,711
Phosphatic chemicals, bagged	32,822	0	32,807	0	0	0	15
Phosphatic chemicals, bulk	3,520,487	517	2,651,201	0	5,446	0	863,323
Phosphoric acid	535,187	0	535,187	0	0	0	0
Phosphorus	248	0	248	0	0	0	0
Sulfur, liquid	3,329,488	744,577	0	2,584,911	0	0	0
Sulfuric acid	32,643	32,643	0	0	0	0	0
Total selected commodities	25,718,028	956,475	14,044,875	2,584,911	171,064	44,146	7,916,556
Total shipments, Port of Tampa	42,020,357	4,323,903	15,022,596	6,289,958	171,064	8,262,322	7,950,514

Source: Port of Tampa Authority.

Table 13.—Relative value and tonnage of various cargoes shipped through the Port of Tampa, 1977

Type of cargo	Percent of total dollar value shipped	Percentage of total tonnage
Phosphate products	34	47
Petroleum products	32	29
Other dry bulk	5	12
Other liquid bulk	9	10
General cargo	20	2
Total	100	100

products alone represented 47 percent of the total tonnage and 34 percent of the total value of shipments handled by the port in 1977 (table 13).

The total economic impact of the port for 1977 was estimated at more than $500 million. Of this total, approximately $200 million was estimated as the primary or direct impact, and $356 million was estimated as the indirect impact. About $77 million of the direct impact was attributed to the handling of phosphate products, and the remaining $123 million was made up of petroleum products, general cargo, and other bulk items (*4*). Direct employment related to the Port of Tampa in 1977 accounted for approximately 5,800 jobs, all but 20 of which were full-time jobs. An additional 24,166 jobs have been identified as being indirectly related to the activities of the port, of which 21,276 were in the phosphate fertilizer sector (*5*). At an average income of $9,000 for each of these 24,166 indirectly related jobs, the total indirect income impact of the port would have been approximately $217 million.

Nearly $500 million in exports of phosphate products was directly handled by the Port of Tampa in 1976, and in 1977 the value of such exports directly handled by the port increased to $580 million. If the value of all outbound phosphate products from the port were accounted for, including domestic shipments, the total value for 1977 would have been more than $600 million.

Phosphate rock and related products accounted for more than 93 percent of all foreign exports that passed through the Port of Tampa in 1977, and nearly all domestic outbound shipments that left the port by ship or barge were also phosphate rock and/or related products (table 12).The largest category of shipments was bulk phosphate rock, of which more than 18 million metric tons was shipped. Of this total, about 60 percent was exported to foreign countries and the rest barged or shipped to domestic ports. Major foreign consumers of bulk phosphate rock were Canada, the Republic of Korea, Japan, France, and the Federal Republic of Germany; each of these countries purchased more than 1 million tons in 1978.

Table 15.—Port of Jacksonville exports of selected commodities related to the phosphate industry, 1970–76

(Metric tons and dollars)

Year	Phosphate rock		Phosphate fertilizers	
	Quantity	Value	Quantity	Value
1976	636,479	22,056,763	119,466	12,754,563
1975	719,155	39,475,829	136,431	33,006,151
1974	1,006,389	23,333,669	115,140	24,759,103
1973	1,117,539	9,031,888	89,001	8,494,945
1972	1,013,255	7,989,651	114,963	8,234,520
1971	936,629	8,204,194	134,805	6,474,821
1970	632,029	5,580,361	100,403	3,860,181

Source: Port of Tampa Authority.

Tampa shipments of phosphatic chemicals totaled more than 3.5 million metric tons in 1977, of which approximately 75 percent was foreign exports. Exports of phosphatic chemicals doubled in volume between 1970 and 1976, and the dollar value of these exports quadrupled during that period (table 14). Major foreign consumers of phosphatic chemicals were Brazil, India, Belgium, France, Italy, Turkey, Mainland China, and the Federal Republic of Germany.

Sulfur (including sulfuric acid) and ammonia were the major input items—either as imports or inbound shipments from other domestic ports—to the Florida phosphate industrial complex via the Port of Tampa. Domestic ammonia and sulfur are acquired from the Gulf Coast area, mainly from Texas and Louisiana. Sulfur is also imported, mostly from Mexico, and ammonia is imported from the U.S.S.R. In addition, the complex is a major user of electricity and therefore an indirect user of petroleum products, which also pass through the Port of Tampa. As shown in table 12, exports amounted to almost 80 percent of the total foreign trade in and out of the Port of Tampa in 1977. This indicates that the port maintained a very favorable balance of trade, largely due to the impact of the phosphate industry.

THE PORTS OF JACKSONVILLE AND BOCA GRANDE[8]

The Port of Jacksonville exports phosphate rock and phosphatic fertilizers. In 1976 exports included about 636,479 metric

[8] See reference map in figure 1.

Table 14.—Port of Tampa imports and exports of selected commodities related to the phosphate industry, 1970–77

(Thousand metric tons and thousand dollars)

Year	Imports: Ammonia		Imports: Sulfur		Exports: Phosphate, bulk and bagged		Exports: Phosphatic chemicals		Exports: Phosphoric acid	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1977	158	NA	745	NA	10,818	[1] 279,196	2,684	NA	535	NA
1976	127	NA	615	NA	7,660	258,206	2,159	238,474	394	NA
1975	140	11,943	632	34,961	8,470	358,443	1,883	389,387	222	42,684
1974	62	6,938	489	18,063	10,013	194,728	942	197,417	125	14,170
1973	83	3,758	50	1,251	9,495	79,049	1,363	118,381	37	2,962
1972	117	5,325	37	916	8,754	77,266	1,129	78,127	33	2,044
1971	140	6,615	107	2,623	8,337	69,610	1,126	59,515	115	4,755
1970	138	6,346	192	5,988	NA	64,908	1,090	55,834	30	1,526

NA Not available.
[1] Based on average export price for 1977.
Source: Port of Tampa Authority.

Table 16.—Port of Boca Grande exports of selected commodities related to the phosphate industry, 1970–76

(Metric tons and dollars)

Year	Phosphate rock		Phosphate fertilizers	
	Quantity	Value	Quantity	Value
1976	107,335	3,892,500	261,632	39,104,937
1975	68,555	2,714,584	213,231	39,248,688
1974	97,978	2,530,572	431,485	84,812,442
1973	307,505	3,564,388	512,491	45,211,667
1972	193,071	1,671,455	356,839	20,239,702
1971	376,217	2,929,789	262,688	13,361,024
1970	434,756	3,492,766	169,145	8,096,090

Source: Port of Tampa Authority.

tons of phosphatic rock and 119,466 metric tons of phosphatic fertilizer products. Although the dollar value of phosphate rock exports more than doubled between 1973 and 1976, the total tonnage dropped in that period by 43 percent (table 15). In that same period there was a 34-percent increase in the tonnage of phosphatic fertilizer, and the value of such shipments increased at about twice that rate, or 67 percent. Phosphate product prices, which had risen sharply in 1974 and 1975, showed signs of leveling off in 1976 and 1977.

Export tonnages of phosphate rock from the Port of Boca Grande have declined; these exports totaled 107,355 metric tons in 1976. The value of phosphate rock exports, however, has increased. Exports of phosphate fertilizers from Boca Grande have declined in recent years, from a peak of 512,491 metric tons in 1973 to 261,632 metric tons in 1976 (table 16).

Rail and Motor Carrier Transportation

RAIL SHIPMENTS

Railroads are the primary means used for shipping large-volume movements of phosphate rock from beneficiation plants to shipping ports and to fertilizer processing facilities. These movements, particularly in the central Florida phosphate region, are very heavy, with some beneficiation plants shipping as many as 150 cars, or 10,000 tons of phosphate rock, each day (*7*). In the central Florida region, multiple-car shipments from several origins are assembled into trains for movement to various destinations within the region, including the Tampa Bay area, or to switching yards for through movement to more distant destinations.

Table 17 lists the tonnages, modes of transportation used by selected Florida industries for shipping goods to other regions of the United States, and the percentage distribution of traffic in various products among these modes. In this table, phosphate products are included in the agricultural chemicals and superphosphates categories. Shipments of agricultural chemicals from Florida represented 22 percent of all the tonnage shipped from the State. Almost all of these shipments originated in the phosphatic fertilizers subindustry of the Florida phosphate industry.

Table 18 shows the geographical distribution of various kinds of agricultural chemicals that were produced in Florida and shipped to other parts of the United States. Based on a sample of waybill data compiled by the U.S. Bureau of the Census, this table indicates that 74 percent of the fertilizer subindustry's shipments went to the South Atlantic region. Most of the shipments recorded for this region were within

Table 17.—Tonnages and means of transportation for selected manufactured goods shipped form Florida to the rest of the United States, 1972

Product	TCC[1]	Quantity shipped, thousand metric tons	Relative share of total shipments, percent							Sampling variability, percent
			Rail	Truck carrier	Private trucks	Air	Water	Other	Unknown	
Chemicals and allied products	28	8,016	76.0	6.4	17.3	0.5	0	0.3	0.2	24
Food and kindred products	20	6,029	31.6	24.0	41.4	0	2.1	.2	1.0	22
Stone, clay, glass, and concrete products	32	5,354	44.8	43.3	11.8	0	0	0	.3	29
Pulp, paper, and allied products	26	2,796	79.8	16.0	3.7	0	.5	0	.2	11
Lumber and wood products, except furniture	24	914	48.5	5.2	45.8	0	0	0	.7	42
Fabricated metal products, except ordinance, machines, and transportation	34	283	8.7	28.3	60.6	0	2.3	.2	0	33
Transportation equipment	37	30	.6	34.1	64.6	.4	0	.4	.2	40
Electrical machines, equipment, and supplies	36	8	.3	52.4	4.9	7.8	8.1	23.9	3.0	47
Tobacco products	21	7	3.6	90.2	1.7	2.1	0	1.0	3.4	11
All other miscellaneous	NAp	3,079	44.6	20.8	29.9	.5	4.0	.4	.2	0
Total	NAp	26,515	54.6	20.8	23.2	.1	1.0	.2	.4	12
Chemicals and allied products, selected sub-categories:[2]										
Agricultural chemicals	287	5,924	80.9	2.6	16.5	0	0	0	.1	30
Superphosphates	28712	4,271	96.8	.4	2.8	0	0	0	.1	37
Industrial inorganic and organic chemicals	281	1,433	80.4	13.0	5.8	0	0	.4	.6	20
Miscellaneous industrial inorganic chemicals	2819	1,301	86.1	10.4	2.7	0	0	.4	.7	22
Sulfuric acid	28193	129	68.5	18.6	9.9	0	0	3.2	0	25
Miscellaneous chemical products	289	15	7.7	77.3	4.6	10.4	0	.1	0	40

NAp Not applicable.

[1] Transportation Commodity Code used in Census of Transportation, 1972, a publication of the U.S. Department of Commerce, Bureau of the Census.

[2] The sum of the quantities shipped for these subcategories is greater than the quantity shipped of chemicals and allied products because some products are included in more than one of these subcategories.

Source: U.S. Department of Commerce, Bureau of the Census (29).

Table 18.—Tonnages and distribution of chemical and allied products manufactured in Florida and shipped to the rest of the United States, by region,[1] 1972

Product	TCC[2]	Total shipments, thousand metric tons	Distribution by region,[3] percent					
			Mid-Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central
Chemical and Allied products	28	8,007	2.0	12.4	7.0	64.9	9.1	3.9
Agricultural chemicals	287	5,554	(4)	12.8	8.9	74.6	(4)	3.7
Superphosphates	28712	3,915	(4)	16.1	6.9	72.8	(4)	4.2
Industrial inorganic and organic chemicals	281	1,429	(4)	17.5	4.3	46.6	25.4	5.8
Miscellaneous industrial and inorganic chemicals	2819	1,301	(4)	19.0	4.7	44.3	26.1	5.9
Sulfuric acid	28193	86	(4)	(4)	(4)	100.0	(4)	(4)
Miscellaneous chemical products	289	8	(4)	25.0	38.0	25.0	12.0	(4)

[1] U.S. Department of Commerce, Bureau of the Census regions (29).
[2] Transportation Commodity Code used in Census of Transportation, 1972, a publication of the U.S. Department of Commerce, Bureau of the Census.
[3] Shipments to the New England, Mountain, and Pacific Regions amounted to less than 1 percent of the total shipments for each of the product categories listed.
[4] Less than 1 percent of total shipments.

Florida and were shipped through the Port of Tampa.

Of the phosphate rock produced by the industry's mining sector, 85 percent was shipped by rail, to points both within and outside the State (table 19). Some phosphate rock was also shipped by rail-barge combination to other parts of the United States, and some was exported. Approximately $54 million in revenue to railroads was generated by phosphate rock traffic in 1976, and the railroads' phosphate revenues for 1977 were estimated at $65 million. These estimates were based on statistics for the Southern District;[9] however, almost all phosphate rock mining in this district took place in Florida.

Total railroad revenue attributed to the industry for all movement of phosphate rock, phosphate fertilizers, and related commodities amounted to $71 million in 1976 and $86 million in 1977, according to the Florida Phosphate Council. Almost all of the $86 million spent in 1977 was directly related to the operations of Seaboard Coast Line Industries, Inc. (SCL), and its subsidiaries in Florida. SCL attributed more than 13 percent, or $229 million, of its total 1977 transportation revenues of $1,678.7 million to its Florida operations. Phosphate industry shipments, including some 19.5 million metric tons of phosphate rock shipped to the Port of Tampa from the central Florida region, represented approximately 37 percent of SCL's total transportation revenues in the State of Florida that year.

TRUCK SHIPMENTS

Truck movement of phosphate rock is used to supplement rail movement during periods of peak production in the central Florida region. Trucks are used as a temporary replacement for rail transportation when rail service is interrupted and as a primary means of transportation where low shipping volumes make rail transport impractical. Almost all truck traffic related to the Florida phosphate industrial complex involves movements of phosphate rock, molten sulfur, and fertilizer between the Port of Tampa and mines and chemical facilities located in Polk County. The Florida Phosphate Council estimated that expenditures for truck transportation amounted to $6.9 million in 1976 and $9.3 million in 1977.

Electric Utilities

The electric utility industry in Florida receives significant revenues from the phosphate industry. Members of the Florida Phosphate Council remitted more than $120 million to the electric power utilities in 1977. Electric power is used by the phosphate industry for mining, for the operation of processing facilities, and for other purposes.

Phosphate industry payments to Tampa Electric Co. in 1977 exceeded $79 million, which was 23 percent of the company's total revenue and 74 percent of its industrial revenue. In the same year Florida Power Corp. received revenues of $41 million from the phosphate industry, which rep-

[9] The Southern District as designated by the Interstate Commerce Commission includes Florida, Tennessee, North Carolina, South Carolina, Georgia, Alabama, Mississippi, southeastern Louisiana, and Kentucky.

Table 19.—Transportation means used for shipments of Florida and North Carolina phosphate rock, by destination, 1976

(Thousand metric tons)

Means of transportation	Destination[1]					
	Florida	Alabama, Arkansas, North Carolina, Tennessee	Illinois, Iowa, Kansas, Michigan, Missouri	Louisiana, Mississippi, Texas	California and Arizona	Export shipments
Rail	13,452	1,559	65	5	39	363
Truck	1,049	(2)	(2)	(2)	(2)	(2)
Barge	(2)	(2)	(2)	(2)	(2)	3,357
Conveyor	1,179	(2)	(2)	(2)	(2)	(2)
Rail and barge	(2)	(2)	(2)	6,573	(2)	10,324
Truck and rail	(2)	(2)	(2)	45	(2)	(2)

[1] Shipments to Idaho, Montana, and Utah amounted to less than 1,000 metric tons for each of the transportation categories listed.
[2] Less than 1,000 metric tons.

Table 20.—Average cost of electric power in Florida for selected industrial uses

(Cents per kilowatt-hour)

Use	Utility	
	Tampa Electric Co.	Florida Power Corp.
Mining:		
1976	2.399	2.672
1977	2.542	2.987
Chemical plants:		
1976	1.199	2.270
1977	1.222	2.566
Electric furnaces:		
1976	2.154	NAp
1977	2.287	NAp

NAp Not applicable.

resented 7 percent of that company's total revenue and 53 percent of its industrial revenue. Florida Power and Light also serves the phosphate industry. In 1977 approximately 64 percent of the electrical power consumed by the phosphate industry was purchased from Tampa Electric, 35 percent from Florida Power, and 1 percent from Florida Power and Light.

Industrial costs for electric power for selected phosphate-related uses are shown in table 20.

A review of electric energy costs to the Florida phosphate industry from 1968 to 1977 showed that the cost of electric energy sold by Florida Power to the mining industry increased by 237 percent during that period. The cost per kilowatt-hour was 0.888 cent in 1968 and had risen by 1977 to 2.99 cents per kilowatt-hour. The largest increase—an increase of more than 100 percent during a 1-year period—was from 1973 to 1974, when the cost of electric energy increased from 1.1 cents per kilowatt-hour to 2.08 cents per kilowatt-hour.

The following tabulation, which shows how a Florida electric company typically spends its revenue, is an example of a forward linkage of the phosphate industry. In this tabulation, the more than $41 million paid to Florida Power by the phosphate industry is broken down, based on the power company's average revenue dollar of expenditures for 1977.

	Percent
Fuel and purchased power	41.5
Interest and other income deductions	7.7
Federal, State, and local taxes	17.8
Dividends	7.1
Payroll and employee benefits	7.4
Provision for property replacement	8.2
Materials, supplies, and other expenses	4.9
Retained in the business	5.4
Total	100.0

Expenditures from revenues could be similarly broken down for Tampa Electric.

State and County Tax Revenues

The phosphate complex is a major generator of tax revenue for the State of Florida. State taxes paid by the industry include the severance tax on minerals, the corporate income tax, the sales and use tax, and vehicle and motor fuel taxes. The industry is also a source of county-level tax revenue in the form of property taxes. The State sales and use tax is an important source of revenue because of the complex purchases of raw materials and constituent parts by the phosphate industry. Also important to the State are sales taxes collected by the industry on sales of phosphate rock, phosphate agricultural chemicals, and industrial chemicals sold to other industries. Table 21 presents a summary of taxes paid by the phosphate complex to State and local governments from fiscal year 1971–72 to fiscal year 1977–78. In the following tabulation, State and county tax revenues from phosphate industry activities are estimated for 1981, in million 1977 dollars:

Table 21.—Selected taxes paid or collected by the Florida phosphate industry complex

(Thousands)

Fiscal year	Ad valorem county-level tax paid	State sales and use tax collected	State corporate income tax paid	Severance tax paid[1]
1977–78	$12,500	$13,800	NA	[2]$41,600
1976–77	9,500	12,850	$2,459	22,056
1975–76	6,700	13,800	3,270	22,322
1974–75	5,800	8,200	5,460	10,838
1973–74	NA	NA	1,712	4,047
1972–73	NA	NA	NA	3,268
1971–72	NA	NA	NA	1,509

NA Not available.

[1] For fiscal years 1971–76, a total of $5,187,000 was returned to the industry in the form of a severance tax credit based on the amount of ad valorem tax paid. (Conditions with respect to land reclamation were also a consideration in the application of this credit.) The credit amounted to about 9 percent of total severance tax collections.

[2] Estimated by Finance, Taxation, and Claims Committee of the Florida Senate, based on value at point of severance of $11.57 per metric ton.

Sources: Florida Phosphate Council and Florida State Department of Revenue.

State corporate income taxes	5.8
State sales and use taxes	25.0
State vehicle and motor fuel taxes	.3
State severence taxes on minerals	48.5
All property taxes paid to counties	20.0
Total projected Florida tax payments	99.6

CORPORATE INCOME TAXES

Florida has had a corporate income tax since January 1, 1972. This tax is collected from all corporations, both domestic and foreign, doing business in Florida. The tax rate is 5 percent of the adjusted Federal corporate income tax owed by the firm, less a $5,900 exemption. Since the tax was instituted, the phosphate industry in Florida has paid the following amounts each year in corporate income taxes, according to the Florida Department of Revenue:

1973	$1,712,150
1974	5,460,341
1975	3,269,859
1976	2,459,228
1977	NA
1981	[e]3,500,000

[e] Estimated. NA Not available.

The total for 1974 was unusually large because it included taxes assessed in 1973 but not paid until 1974. In addition to the 1981 estimate of $3.5 million in corporate income tax payments by the phosphate industry, it was projected that other industries would pay $2.3 million in corporate income taxes attributable to phosphate industry activity. The effect

of the phosphate industry's activities on other industries is described later with respect to output in the subsection, "Output Effect."

SALES AND USE TAXES

The Florida sales and use tax is the State's primary source of revenue. The tax rate is 4 percent of final sales, but there are many general and specific exemptions. In 1977 the phosphate complex paid more than $14 million in Florida sales taxes, and it is expected to pay an estimated $15.7 million in 1981. Based on this estimate, total State sales tax revenues attributable to phosphate-related output are expected to exceed $25 million in 1981. Fertilizers and animal feeds, which constitute an important part of the phosphate industry's total sales, are exempt from the sales tax. Without this exemption, phosphate-related sales tax revenues would be much larger.

VEHICLE AND MOTOR FUELS TAXES

The Florida Phosphate Council reported that its members paid $192,000 in State vehicle and fuel taxes in 1977; however, the total tax paid as a direct result of industry-related activity was much larger. Vehicle and motor fuel taxes paid by other firms and industries as a direct result of phosphate industry activity were estimated based on interindustry dependency coefficients calculated from an I-O table. Based on these estimates, it was estimated that in 1981 more than $300,000 in State vehicle and motor fuel taxes would be attributable to activity related to the phosphate industry. This forecast was based on a fiscal impact or revenue multiplier that is analogous to the output multipliers subsequently described under the subheading, "Output Effect." The revenue multiplier was calculated from estimates of revenue generated through the backward linkage for the support of materials to the production process.

SEVERANCE TAXES

The State's solid minerals severance tax has been in effect since July 1, 1971, when the tax rate was set at 3 percent. The tax rate is applied to a value set by the State for phosphate rock at the point of severance. State law originally provided for a gradual increase in the tax rate, and the rate was raised to 4 percent beginning July 1, 1973, and was subsequently raised to 5 percent beginning July 1, 1975. In 1977 a Phosphate Land Reclamation Study Commission was created to examine the land reclamation practices of the State's phosphate rock mining operations, and the commission's most important recommendations were published as a report (*14*). As a result of this study, the severance tax rate on phosphate rock was increased in 1978 from 5 to 10 percent. Tax payments beginning with the 1978 tax year were to be made quarterly; previously, the tax was paid in a single annual payment that was due April 1. The value set by the State for computation of the severance tax on phosphate rock may vary from year to year. This value increased to $12.84 per metric ton in 1977 from the previous value of $10.50 per metric ton.

Severance tax collection's from the phosphate industry are shown in the following tabulation, in million dollars:

1973–74	3.4
1974–75	9.6
1975–76	20.1
1976–77	20.0
1977–78	[1]41.6
1978–79	[1]42.2
1979–80	[2]48.5

[1]Estimated by the Finance Taxation and Claims Committee of the Florida Senate, based on the pre-1978 point-of-severance value of $10.50 per ton.
[2]Estimated by the Bureau of Mines.

A tax credit is available to the mining industry for the reclamation of mined land. Land reclamation has been mandatory since 1975, when a prior distinction between "old lands" (lands mined or disturbed by the severance of phosphate prior to July 1, 1975) and "new lands" was eliminated. The tax credit program requires producers to develop programs of reclamation and restoration that must be approved by the Florida Department of Natural Resources.

Under the tax credit program, producers are allowed to credit up to 20 percent of ad valorem taxes against the severance tax, except that the credit may not exceed the total amount of ad valorem taxes remitted on a specific parcel of mining property. Of the total phosphate severance tax, 75 percent goes to the Land Reclamation Trust Fund, and 25 percent goes to the State's General Revenue Fund. Refunds of up to 100 percent of the amount paid to the reclamation trust fund are allowed for approved plans for mine site reclamation.

Table 22.—Florida acreage distributed by phosphate mining and acreage in various stages of reclamation, 1976

Producer	Acreage included in reclamation programs			Acres disturbed by mining, 1976	Acres disturbed by mining, July 1, 1975, to Dec. 31, 1976
	Reclamation in progress, 1976	Reclamation completed, 1976	Total reclamation completed, July 1, 1971 to Dec. 31, 1976		
Agrico Chemical Co.	2,082	872	2,178	1,430	2,185
Borden Chemical Co.	737	465	964	176	275
Brewster Phosphate Co	1,084	838	929	375	680
Gardinier, Inc.	327	80	325	278	400
International Minerals & Chemical Co.	1,978	1,301	3,194	1,278	1,932
Mobil Chemical Co.	698	10	768	627	901
Occidental Agricultural Chemical Co.	431	374	483	782	1,075
Swift Chemical Co.	529	106	449	376	549
T.A. Minerals Corp.	27	0	0	37	37
U.S.S. Agri-Chemicals, Inc.	358	158	280	274	423
W. R. Grace & Co.	188	102	1,165	255	425
Total	8,439	4,306	10,735	5,888	8,882

Source: Florida Department of Natural Resources, Division of Resource Management, Bureau of Geology.

Table 23.—Selected millage rates for the Florida ad valorem tax, 1976

County	County rate	Schools rate	Total
Polk	5.5390	8.0000	13.5390
Hillsborough	6.0470	8.0000	14.0470
Hamilton	6.0290	8.0000	14.0290
Columbia	6.6920	7.6970	14.3890
Manatee	7.0580	8.0000	15.0580
Hardee	4.6620	6.3000	10.9620
Pasco	7.6450	8.0000	15.6450
Hernando	6.0760	8.0000	14.0760
Citrus	8.1240	8.0000	16.1240
Levy	7.1000	7.8140	14.9140
Marion	3.1800	8.0000	11.1800
Gilchrist	5.9146	6.3000	12.2146
Alachu	7.1931	8.0000	15.1931
Putnam	9.2600	7.4000	16.6600
Lafayette	3.0000	6.3000	9.3000
Pinellas	5.5400	8.0000	13.5400
DeSoto	7.9020	8.0000	15.9020

The tax credit for land reclamation can be accumulated over time, but after 5 years, unclaimed reclamation funds revert to the General Revenue Fund. Since the inception of the severance tax, the phosphate industry has paid more than $100 million in severance tax payments. Of this total, more than $24 million has been refunded to mining companies for the completion of reclamation projects. A summary of recent reclamation activity is presented in table 22.

AD VALOREM PROPERTY TAXES

According to the Florida Phosphate Council, members paid a total of $12.5 million in property taxes in 1977. Most of these taxes were paid to county and local governments in the central Florida region. In table 23, the ad valorem tax millage rates are listed for selected counties. It was estimated that the phosphate industry will pay more than $20 million in property taxes in 1981.

Output Effect

Marketable production of phosphate rock in Florida exceeded 40 million metric tons in 1978. Based on an estimated production of 43 million metric tons in 1981 for Florida alone, it was projected that the direct output (sales) by the Florida phosphate industry for that year would total approximately $870 million, in 1977 constant dollars. This projection of direct output included $303 million for phosphate rock shipped directly out of the region to foreign countries or domestic consumers and $567 million for phosphate fertilizer processed in the State from Florida phosphate rock.

The total effect of phosphate production, however, is much larger than $870 million. An additional output effect of the industry is in the form of sales of goods and services by second-level suppliers to the phosphate industry. Furthermore, phosphate industry activity generates sales by third-level suppliers to the second-level suppliers. Added together, the industry-related sales of the second- and third-level suppliers constitute an *indirect output effect* of the phosphate industry which can in turn be added to the direct output. Succeeding levels of suppliers can also be included, but their contribution to the total output effect becomes less and less significant.

The output multipliers for the phosphate industry measure the sum of direct and indirect requirements from all economic sectors needed to deliver one additional dollar of output from the phosphate industry to final demand (the consumer). These multipliers were derived from a Leontief inverse matrix[10] which showed the direct and indirect requirements per unit (dollar) of final demand for each sector. To obtain the output multipliers, phosphate industry data from the matrix were totaled. The total multiplier for Florida phosphate rock mining and beneficiation was estimated to be 1.5440, and the multiplier for Florida fertilizer manufacturing was estimated to be 1.5738. The magnitude of the Florida phosphate industry's output effect is apparent from the $1.4 billion that was estimated as the industry's total combined output effect for 1981.

Employment Effect

Phosphate industry employees are among the highest paid industrial workers in central Florida; they are also among the highest paid workers in the State. Of all manufacturing employees in Polk County, phosphate industry employees earn the highest hourly wage and work the lowest number of hours per week. Similarly, in northern Florida, the highest labor

[10] The Leontief inverse matrix was derived from a direct requirements I-O table prepared for the State of Florida.

Table 24.—Comparison of labor force, earnings, and hours worked for selected industries in Polk County and the State of Florida, 1977

Industry	Annual labor force[e]	Annual wages[1]	Hours worked per week[1]	Hourly earnings[1]
Polk County:				
Phosphate rock mining and beneficiation	4,487	$13,476	44.3	$5.85
Phosphate fertilizer manufacturing	4,131	12,789	44.8	5.49
Citrus food products	5,299	8,586	48.0	3.44
All manufacturing	19,100	10,765	45.1	4.59
State of Florida:				
Phosphate rock mining and beneficiation	5,190	13,476	44.3	5.85
Phosphate fertilizer manufacturing	8,592	13,699	45.5	5.79
Citrus food products	13,783	9,030	45.7	3.80
All manufacturing	374,600	9,799	40.7	4.63

[e] Estimated.
[1] Average.
Source: Florida Department of Commerce, Division of Employment Security.

Table 25.—Effect of Florida phosphate industry output, employment, and income on the on the State of Florida, as projected for 1981

	Phosphate rock mining and beneficiation	Phosphate fertilizer production	Industrial inorganic chemicals[1]	Combined impact
Output effect, million 1977 dollars:				
Direct	303	567	0	870
Indirect	165	325	0	490
Total	468	892	0	1,360
Employment effect, number of jobs:				
Direct	7,030	5,147	377	[2]12,554
Indirect	6,214	3,812	305	10,331
Induced	16,343	8,375	896	25,614
Total	29,587	17,334	1,578	48,499
Income effect, million 1977 dollars:				
Direct	93.7	68.6	5.0	[3]167.3
Indirect	50.7	52.9	2.2	105.8
Induced	92.3	77.5	4.6	174.4
Total	236.7	199.0	11.8	447.5

[1] Primarily elemental phosphorus.
[2] Based on a projected of 43 metric tons in 1981 and the assumption that an average of 291.92 workers will be required per million tons of output.
[3] Based on the assumption that a total of 12,554 employees will be working in the industries listed above in 1981, at an average of $13,329 per year.

wage is earned by workers at the Hamilton County phosphate operations of the Occidental Agricultural Chemical Co.

The importance of phosphate industry employment to the central Florida regional economy is illustrated in table 24, which shows how wage and employment levels in the phosphate industry compare with those of selected other industries. This table also shows how Polk County wage and employment levels compare with those of the State as a whole for these industries.

In addition to the high rate of pay they earn, phosphate industry employees work steadily the year round with little or no layoff time, whereas employment in the citrus food products industry, for example, is seasonal. The steady flow of wages and salaries generated by the phosphate industry helps provide a stable economy in central Florida.

Table 25 shows estimated employment for 1981 for phosphate rock mining and beneficiation, phosphate fertilizer production and inorganic industrial chemicals production in the State of Florida. As shown in this table, it was estimated that 12,554 workers will be directly employed in the Florida phosphate industry in 1981 (based on a projected output of 43 million metric tons of phosphate rock). The total number of jobs expected to be impacted by the production of Florida phosphate products in 1981 was estimated at more than 48,000. This total includes workers who are directly employed by the industry as well as those whose jobs are either indirectly related to the phosphate industry or induced by phosphate industry activity. (*Induced employment* includes any jobs that support primary and secondary employment, such as retail and service employment.)

INCOME EFFECT

Table 25 shows that the total income effect expected to be generated by the Florida phosphate industry in 1981 was estimated at $447.5 million. *Total income effect* refers to the sum of direct, indirect, and induced income; *induced income* is all tertiary and subsequent income generated. Of the total income effect estimated for 1981, direct and indirect income totaling $273.1 million was included in an estimate of the industry's total 1981 output effect. This estimate of the industry's output effect, $1,360 million, is also shown in table 25. The remainder of the total income effect, $174.4 million, is induced income. The total income effect was calculated based on a *type II multiplier,* which is the ratio of the direct, indirect, and induced income change to the direct income change when final demand is increased by one unit. A more detailed explanation of type II multipliers is given in appendix A.

Table 26.—Distribution of operating costs[1] in the Florida phosphate industry, 1977

(Thousands)

Expenditure item	Within-Florida costs	Total costs, including out-of-State
Trucking	$9,300.0	$9,300.0
Railroad transportation	86,000.0	86,000.0
New construction	[2]126,000.0	[2]163,000.0
Electric power	120,200.0	120.200.0
Sales taxes	13,800.0	13,800.0
Shipping firms, barges, etc	21,000.0	21,000.0
Equipment, supplies (including raw materials), and services	309,000.0	612,000.0
Property taxes, county	12,500.0	12,500.0
Telephone service	1,800.0	1,800.0
Vehicle fuel tax, State	192.0	192.0
Payroll	[3]164,000.0	[3]164,000.0
Severance tax, State	42,400.0	42,400.0
Natural gas distribution	13,200.0	13,200.0
Total	919,392.0	1,259,392.0

[1] Estimated.
[2] These figures may include capital outlay misidentified as new construction; this could not be determined.
[3] Assuming that total payroll was expended in Florida.
Source: Florida Phosphate Council.

Table 27.—Estimated operating costs and capital expenditures for the Florida phosphate industry, 1978

(Million 1977 dollars)

Industry	Operating costs	Capital expenditures
Phosphate rock mining and beneficiation	490.0	421.3
Phosphate fertilizer manufacturing:		
Phosphate acid, wet process	687.0	463.3
Ammonium phosphate	250.3	63.6
Concentration superphosphate	148.5	95.8
Total	1,575.8	1,044.0

CAPITAL EXPENDITURES AND OPERATING COSTS

Phosphate industry expenditures are estimated by item for 1977 in table 26. This item-by-item expenditure-allocation table shows fairly accurately the distribution of operating costs for the industry. (It is possible, however, that certain capital outlays may have been misidentified and included in this table as expenditures for new construction; but this could not be determined.)

Estimates of total operating costs and capital expenditures for the Florida phosphate industry in 1978 are given in table 27. The value of replacement capital expenditures, estimated at more than $1.0 billion, represents almost two-thirds of estimated total operating costs.

Because of concern for the environment and the cost of compliance with new environmental laws, the U.S. Bureau of the Census has identified pollution abatement costs and capital expenditures for the major manufacturing industries, including those of the Florida phosphate fertilizer processing subindustry. Of the two totals shown in table 27, $14.1 million in capital expenditures and $20.9 million in total operating costs were identified as pollution abatement costs and expenditures for the phosphate fertilizer processing part of the industry (*30*).

Summary

The Florida phosphate industrial complex is forecast to produce the following value of output in 1981 and provide the following employment, income, and revenue benefits to Florida (directly, indirectly, or by induced effects):

Total output .... $1,360 million
Total employment .... 48,499 jobs
Total personal income .... [1]$447.5 million
Total tax revenue .... $99.6 million

[1] Of this amount, $273.1 million is also included in the $1,360 million total output figure.

NATIONAL SIGNIFICANCE OF THE FLORIDA PHOSPHATE INDUSTRY

Domestic Profile

The central Florida phosphate district is the largest phosphate producing region in the world. In 1978 domestic production of marketable phosphate rock reached a recond high of 50 million metric tons, of which approximately 40 million metric tons was from Florida. Based on projected production levels, it is expected that the central Florida phosphate district will continue to be a significant source of phosphate rock for the foreseeable future. If recent projections prove correct, however, production in central Florida will decline after 1987. Also, if certain economic conditions change, the life expectancy of the district's reserves would be expected to change accordingly.

Most of Florida's phosphate rock production comes from the Bone Valley Formation in Polk and Hillsborough Counties. This formation is unique and has been a principal world source of phosphate rock. From a cost-of-production point of view, it is far superior to any other known foreign or domestic phosphate deposit. The Bone Valley deposit has well-defined geographical limitations, and certainly at some future date it will be depleted. Production levels are eventually expected to diminish because of increases in capital costs and depletion of the reserves. Other possible limitations to capacity replacement and future growth include environmental and other Government regulation, productivity lags, and inadequacy of Florida's transportation system for phosphate rock. These and other factors expected to affect the future output of the Florida phosphate industry are discussed fully in appendix D.

Florida's phosphate industry has access to both domestic and international trade through the Ports of Tampa, Boca Grande, and Jacksonville. In terms of access to eastern and many midwestern domestic markets, Florida's phosphate producers have several advantages over phosphate producers from the Western States.[11] One advantage is Florida's proximity to the Mississippi River, which provides direct access to the farming heartland of the United States, where much phosphate is used in the form of fertilizers. Extensive barge transshipment services that utilize the Mississippi and other rivers (fig. 5) are also available to the Florida producers. In addition, overland transportation costs to the eastern markets and many of the midwestern markets are lower from Florida. From figure 6, which shows the rail transportation rates for selected interstate movements of phosphate rock, it is apparent that the overland distances and shipping costs to these markets are less from central Florida than from the western phosphate producing States. Moreover, Florida's phosphate rock mining production costs are lower than those of the western operations. Because of these cost advantages, Florida phosphate producers are able to furnish domestic consumers with some of the lowest cost fertilizer available.

In 1976 the Corn Belt (which is identified in figure 7) accounted for 33 percent of U.S. phosphatic fertilizer consumption. The Northern Plains States, Great Lakes States, and Appalachian States together used 31 percent of the domestic supply. The Mississippi River and its tributaries provide convenient, low-cost water transportation to these areas. Together with the Delta States and the Southern Plains States, these areas accounted for 75 percent of domestic phosphatic fertilizer consumption in 1976. Consumption shares for these and other U.S. regions are shown in figure 7.

[11] The major producers of phosphate rock among the Western States are Idaho, Montana, Utah, and Wyoming.

U.S. Supply and Demand

U.S. phosphate rock production has increased steadily over time (fig. 8) and in 1978 reached an alltime high, as shown in table 28. Florida and North Carolina accounted for about 11 percent, and Tennessee accounted for 4 percent. The total value of marketable phosphate rock production from 1960 to 1977 is illustrated graphically in figure 9. The average unit values of this production (per metric ton) are listed in table 29 and are also shown graphically in figure 10.

The Florida phosphate industry consists mainly of a relatively small number of large, vertically integrated companies that mine and beneficiate phosphate rock and also manufacture fertilizers and related chemicals. Table 30 lists Florida's phosphate rock producers, and these producers are located by reference numbers (as identified in the table) on the map in figure 11. In 1977 Florida's 16 producers of phosphate rock operated at between 85 and 97 percent of their production capacity.

Table 31 lists companies that manufacture phosphate products, and figure 12 shows the location of their plants across the United States (again through the use of reference numbers). As shown in table 32, Florida's phosphatic fertilizer production capacity for 1978 exceeded the total capacity of the rest of the Nation. In 1978 Florida operations had the capacity to produce 58.4 percent of the Nation's wet-process phosphoric acid, 50.3 percent of its ammonium phosphate, and 74.6 percent of its concentrated superphosphate.

In addition to the 16 firms engaged in phosphate rock mining in Florida, 8 other firms mine phosphate rock in the United States. Some of these 24 companies operate in more than one State. There are four phosphate rock mining operations in Tennessee, five in Idaho, and one each in North Carolina, Utah, Alabama, and Montana. Phosphate rock mining operations in States other than Florida are listed in table 33, and their locations are shown (by reference numbers) in figure 11.

In 1978 the value of U.S. phosphate rock production exceeded $928 million, as shown in table 34. Approximately 88 percent of this production was processed by domestic companies into agricultural fertilizers at locations shown in table 31 and figure 12. The rest was used in animal feed, detergent manufacture, and miscellaneous applications, as shown in figure 13. A breakdown of domestic phosphate rock use in 1977 according to geographic area is shown in figure 14.

Domestic demand for phosphate rock in 1978 was 35.9 million metric tons, as shown in table 35. Based on a projected annual growth rate of 2 to 3 percent, domestic demand by 1985 would be more than 45 million metric tons (*20*). It was estimated that fertilizer demand, the major factor in this projected growth, will account for 85 percent of the domestic demand for phosphate rock in 1985. Florida phosphate rock production in 1985 was estimated at approximately 54 million metric tons, of which about 12 million tons is expected to be exported. Total U.S. exports of phosphate products, in phosphate rock equivalence, were estimated at more than 26.5 million metric tons for 1978 (table 36).

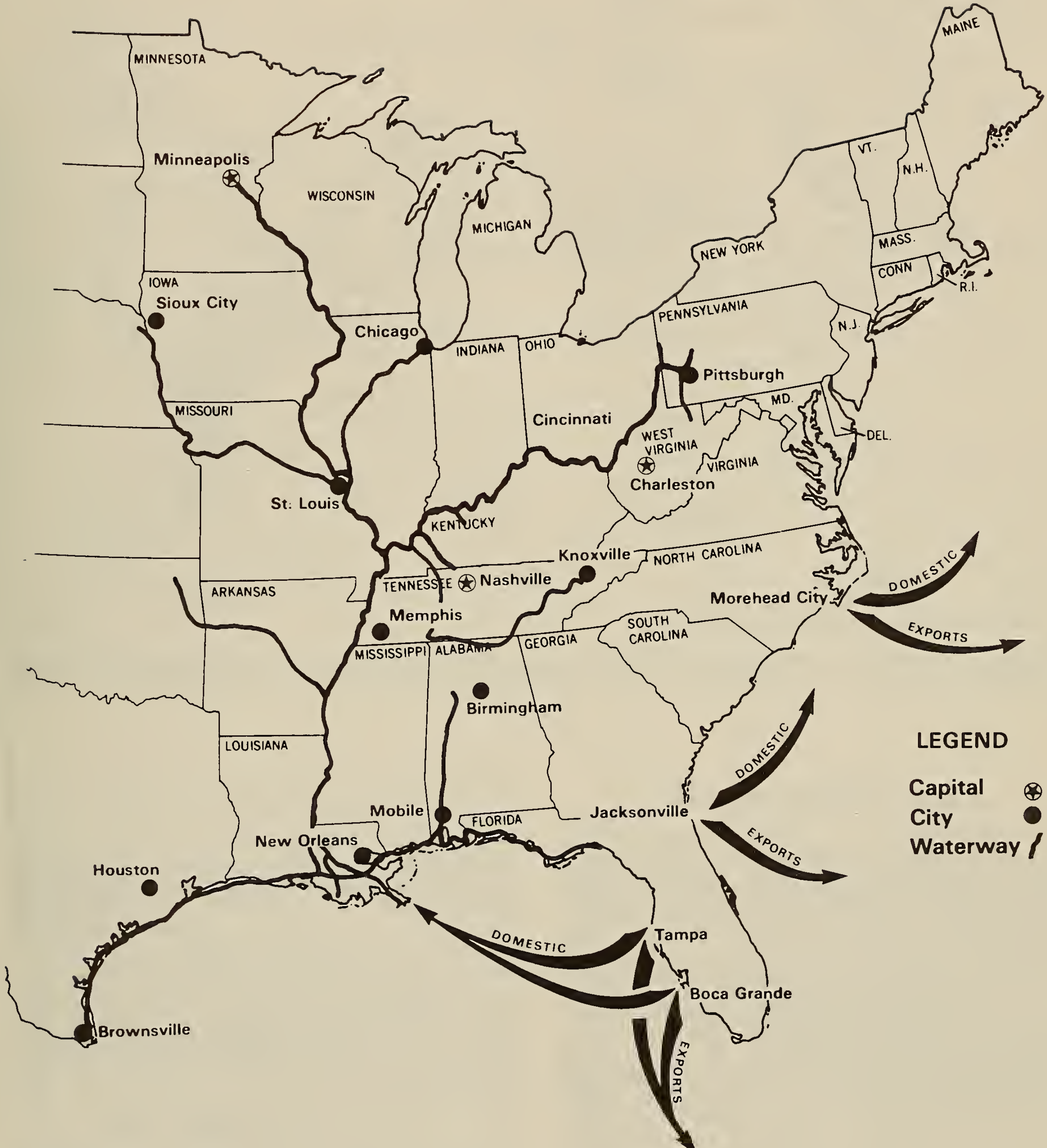
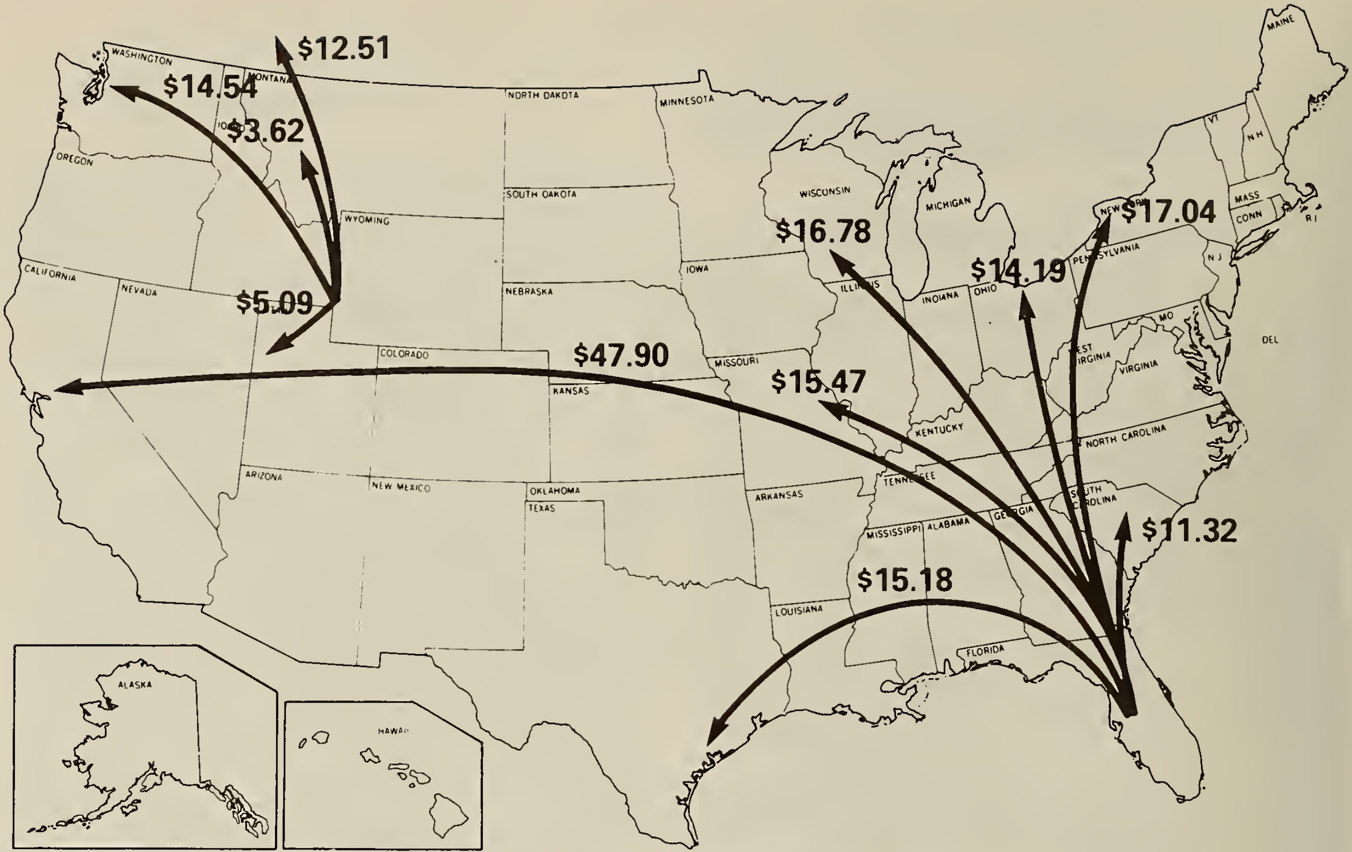


Figure 5.—Inland, intracoastal, and ocean water routes available for ship and barge movement of phosphate rock in the Eastern United States.



SOURCE: INTERSTATE COMMERCE COMMISSION

Figure 6.—Rail rates at ex parte 336 level for selected movements of phosphate rock (estimates based on rates per net short ton of rock).

Income, Employment, and Output

Input-output (I-O) multipliers were used to estimate the total nationwide impacts of the Florida phosphate industry on income, employment, and output. These multipliers were based on a national I-O table that included data for 404 industrial sectors.

The results of this analysis are presented in table 37, which represents an expansion of the data presented in table 25 on the combined statewide impacts of Florida phosphate operations on income, employment, and output. Using the I-O multipliers, it was estimated that $391 million in indirect and induced income will be generated by the Florida phosphate industry outside the State in 1981; this would bring the nationwide total income generated by Florida phosphate operations to $838.5 million. Similarly, it was estimated that some 60,000 jobs outside the State will be attributable to the indirect and induced effects of the Florida phosphate industry in 1981, and the direct and indirect output expected to be generated by the Florida industry outside the State was projected at $1.4 billion. Through addition of the State and rest-of-Nation estimates, it was estimated that on a national level the Florida phosphate industry in 1981 can be expected to account for 108,000 jobs and approximately $2,765 million in gross output.

Taxes

Estimates of the fiscal benefits expected to be associated with the Florida phosphate industry in 1981 are shown in table 38, based on 1977 dollars. It was previously estimated that the industry would pay out $99.6 million in Florida tax revenues (see the subsection, "State and County Tax Revenues.") In addition, Federal tax revenues and tax revenues to other States attributable to the Florida phosphate industry and related activities were estimated at $217 million for 1981. This means that a total of $316.6 million in Federal and State tax revenues can be expected to be generated by the Florida phosphate industry in 1981.

PERSONAL INCOME TAXES

Based on the assumption of an effective income tax rate of 7 percent, Federal personal income tax revenues of at least $58 million would be realized from the previously estimated $838.5 million (table 37) in income expected to be generated nationwide by the Florida phosphate industry in 1981. The 7 percent rate was based on the assumption that an employee would be married, have two children, and claim the standard deduction. Since Florida has no State personal income tax, there is no State tax revenue from phosphate

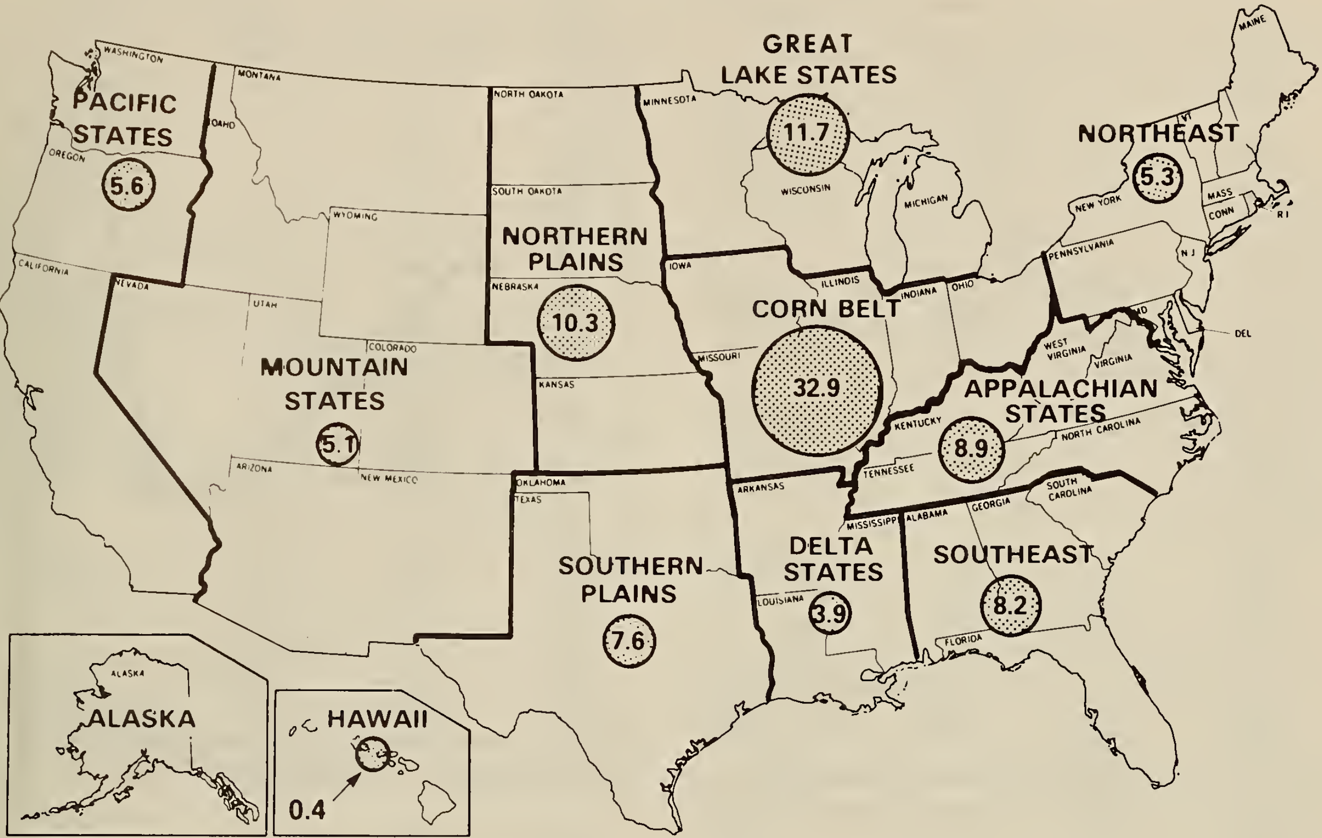


Figure 7.—Domestic use of phosphate as fertilizer, by region, in 1976 (percent of total).

industry employees. However, personal income tax revenue to States other than Florida from income generated by the Florida phosphate industry was estimated at more than $2 million for 1981. Thus, the total Federal and State income tax contribution resulting from Florida phosphate industry activity in 1981 can be expected to be at least $60 million, as shown in table 38.

CORPORATE INCOME TAXES

A Federal corporate income tax rate of 4 percent of the total value of phosphate-related output was assumed for 1981. By applying this rate to the $2,765 million projection of total output value expected to be generated by the Florida phosphate industry in 1981 (table 37), it was estimated that $110.6 million in Federal corporate income tax payments will result from the industry and its related activities in that year. State corporate income tax rates were calculated, based on U.S. Internal Revenue Service publications, to average about 0.85 percent of gross output. By applying this rate to total phosphate-related output outside Florida, the estimated contribution of the Florida phosphate industry to other States' corporate income tax revenue was projected at about $12 million for 1981. Therefore, total Federal and State corporate income tax revenue from the Florida phosphate industry and its related activities for 1981 was estimated at about $128.4 million.

SALES AND PROPERTY TAXES

Sales tax payments generated by the phosphate industry were estimated for States other than Florida by applying a rate of 0.31 percent (based on national averages of taxes paid) to the estimated total rest-of-Nation output of $1,405 million for 1981 (table 37). The resultant estimate of $4.4 million, together with the Florida sales tax estimate of $25 million for 1981 (table 38), indicates that more than $29 million in State sales tax payments will be generated by the Florida phosphate industry and related activities in that year.

Similarly, it was estimated that the industry and its related activities in 1981 will generate $20 million in Florida ad valorem property taxes and $30 million in ad valorem property taxes paid to other States (or divisions thereof), or $50 million in total ad valorem property taxes nationwide (table 38).

Effects on U.S. Balance of Payments

It was estimated that by 1981 the Florida phosphate industry could make an annual positive contribution to the U.S. balance of payments of approximately $961.8 million. A breakdown of this estimate is shown below (based on the assumption that there will be no increase in price for the products listed).

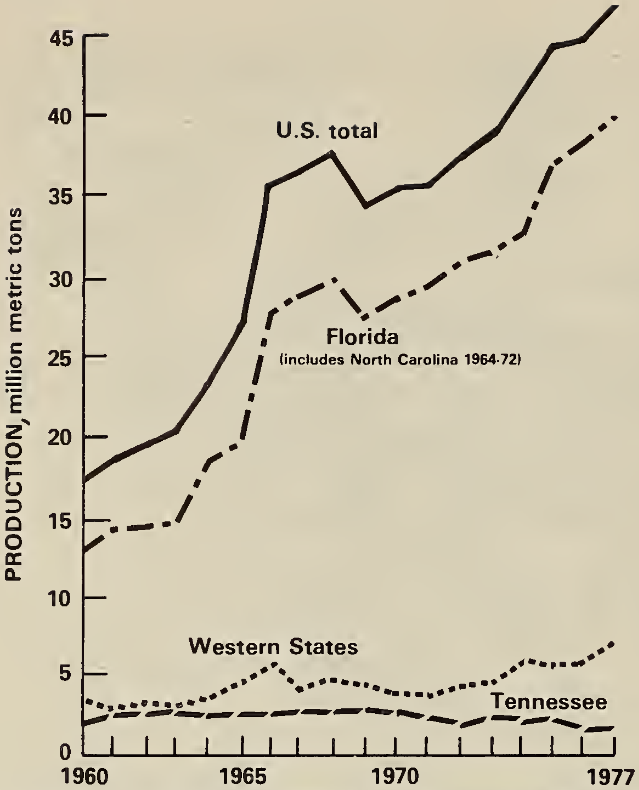


Figure 8.—Geographic breakdown of marketable phosphate rock production in the United States, 1960–77.

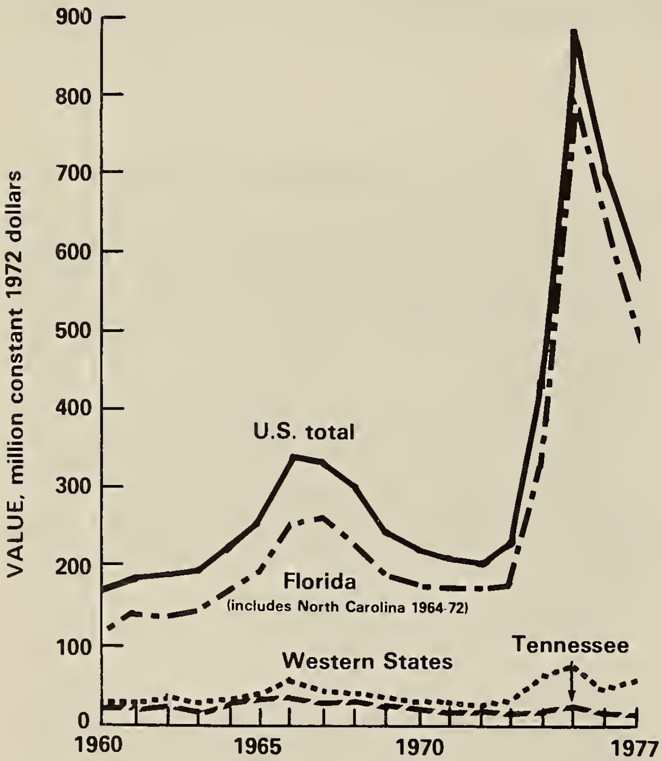


Figure 9.—Value of U.S. marketable phosphate rock production, by geographic area, 1960–77.

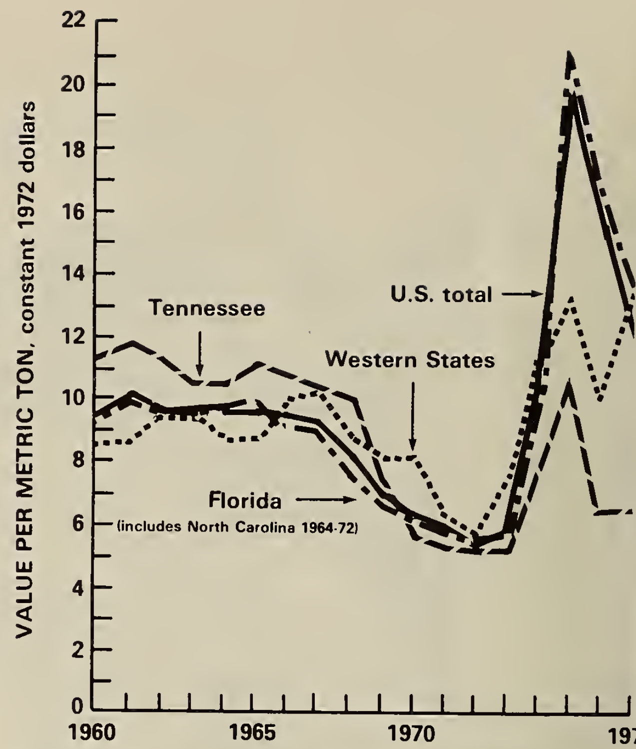


Figure 10.—Average value of U.S. marketable phosphate rock production, by geographic area, 1960–77.

Exports of phosphate rock	510.0
Exports of phosphatic fertilizer	500.0
Imports of sulfur	−53.5
Potential reduction of fluorine imports	5.3
Total (net)	961.8

Included in this estimate is the positive effect of exports of Florida phosphate rock and agricultural chemicals and the negative effect of imports of sulfur to Florida for sulfuric acid production. Also included is the value of fluosilicic acid produced in Florida, which reduces U.S. imports of fluorspar by a proportional amount.

In 1978 the United States exported a total of 20,890,000 metric tons of phosphate rock and fertilizer products valued at more than $1.3 billion. Of this total, 95 percent was from Florida (including a small amount from North Carolina). Included in this total were ammonium phosphates valued at $579.8 million; triple superphosphates worth $143.2 million; natural phosphate fertilizer, $25.6 million; Florida land pebble, $341.1 million; wet-process phosphoric acid (P_2O_5), $91.9 million; and smaller amounts of other fertilizers. Exports of phosphate products from Florida were valued at more than $1.0 billion in 1978.

Total exports of phosphate rock from Florida alone for 1981 were projected at 17 million metric tons. Assuming an average export price for the first half of 1979 of $24.55 per metric ton, f.o.b. Port of Tampa, Florida phosphate rock exports in 1981 would be worth approximately $510 million. If it is further assumed that exports of phosphate fertilizers from Florida ports in 1981 will be worth $500 million, the total value of Florida's exports of phosphate products (phosphate rock plus fertilizers) would be more than $1 billion in 1981.

Florida ranks first in the United States in sulfuric acid pro-

Table 28.—Marketable production of phosphate rock in the United States, by geographic area, 1960–78

Producing area	Quantity, thousand metric tons	Value, thousand (constant 1972) dollars	Value, thousand (current) dollars
1960:			
Florida	12,519	119,974	82,386
Tennessee	1,970	22,457	15,421
Western States[1]	3,309	28,413	19,511
U.S. total[2]	17,789	170,843	117,318
1961:			
Florida	14,011	139,104	96,371
Tennessee	2,271	26,915	18,647
Western States[1]	2,575	22,620	15,671
U.S. total[2]	18,857	188,639	130,689
1962:			
Florida	14,173	136,189	96,081
Tennessee	2,457	27,943	19,714
Western States[1]	3,064	29,103	20,532
U.S. total[2]	19,693	193,235	136,327
1963:			
Florida	14,826	143,136	102,471
Tennessee	2,390	25,093	17,964
Western States[1]	2,957	28,096	20,114
U.S. total[2]	20,173	196,325	140,549
1964:			
Florida[3]	17,389	167,663	121,908
Tennessee	2,480	26,058	18,947
Western States[1]	3,460	30,371	22,083
U.S. total[2]	23,329	224,093	162,938
1965:			
Florida[4]	19,562	190,067	141,258
Tennessee	2,679	30,00	22,296
Western States[1]	4,463	39,268	29,184
U.S. total[2]	26,704	259,334	192,738
1966:			
Florida[4]	27,059	254,171	195,102
Tennessee	2,835	31,118	23,886
Western States[1]	5,527	54,851	42,104
U.S. total[2]	35,420	340,141	261,092
1967:			
Florida[4]	28,948	262,956	207,788
Tennessee	2,714	28,564	22,571
Western States[1]	4,416	45,037	35,588
U.S. total[2]	36,079	336,557	265,947
1968:			
Florida[4]	29,966	234,127	193,319
Tennessee	2,857	28,616	23,628
Western States[1]	4,599	40,870	33,746
U.S. total[2]	37,422	303,611	250,692
1969:			
Florida[4]	27,152	185,398	160,777
Tennessee[5]	2,970	21,780	18,888
Western States[1]	4,101	33,469	29,024
U.S. total[2]	34,224	240,647	208,689
1970:			
Florida[4]	28,375	174,006	158,972
Tennessee[5]	2,869	16,919	15,457
Western States[1]	3,898	31,521	28,789
U.S. total[2]	35,143	222,437	203,218
1971:			
Florida[4]	29,167	174,706	167,753
Tennessee	2,332	12,655	12,151
Western States[1]	3,778	24,916	23,924
U.S. total[2]	35,277	212,277	203,828
1972:			
Florida[4]	30,954	173,910	173,910
Tennessee	1,954	10,732	10,732
Western States[1]	4,132	23,268	23,268
U.S. total[2]	37,040	207,910	207,910
1973			
Florida[4]	31,232	181,147	191,654
Tennessee	2,279	12,097	12,799
Western States[1]	4,716	32,338	34,214
U.S. total[2]	38,226	225,583	238,667
1974:			
Florida[4]	33,548	352,507	408,979
Tennessee	2,187	15,915	18,465
Western States[1]	5,711	63,769	73,985
U.S. total[2]	41,446	432,192	501,429
1975:			
Florida[4]	36,922	786,750	1,000,352
Tennessee	2,078	22,653	28,803
Western States[1]	5,284	73,165	93,029
U.S. total[2]	44,285	882,567	1,122,184
1976:			
Florida[4]	37,697	648,245	867,092
Tennessee	1,634	10,860	14,527
Western States[1]	5,340	50,647	67,746
U.S. total[2]	44,671	709,753	949,365
1977:			
Florida[4]	40,575	507,304	718,393
Tennessee	1,747	10,065	14,253
Western States[1]	4,934	62,856	89,011
U.S. total[2]	47,256	580,225	821,657
1978:			
Florida[4]	43,258	537,290	817,165
Tennessee	1,709	9,236	14,047
Western States[6]	5,070	64,178	97,608
U.S. total[2]	50,037	610,704	928,820

[1] Includes Arkansas (1963–66 and 1973–77), California (1968–70 and 1973–77), Idaho, Missouri, Montana, Utah, and Wyoming.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes North Carolina production of approximately 6,350 metric tons.
[4] Includes North Carolina.
[5] Includes Alabama.
[6] Includes Alabama, Utah, Wyoming, Montana, and Idaho (1978).

duction, most of which is captive production for the phosphate industry. In 1978 the Florida phosphate industry consumed 775,949 metric tons of imported sulfur. Using the 1978 year-end value of sulfur of $69 per ton, these imports represented a $53.5 million negative contribution to the U.S. balance of payments. This negative contribution is chargeable to the Florida phosphate industry, since this sulfur would not have to be imported if the Florida phosphate industry did not exist. If conditions remain basically the same, $53.5 million can also be expected to represent the value of sulfur imports for the phosphate industry in 1981.

Fluorine in the form of fluosilicic acid is recovered from phosphoric acid plants in Florida and in other States from Florida phosphate rock. Fluorine has metallurgical applica-

Table 29.—Average values of marketable phosphate rock production in the United States, by geographic area, 1960–78

Producing area	Value per metric ton: Constant[1] 1972 dollars	Value per metric ton: Current dollars
1960:		
Florida	9.58	6.58
Tennessee	11.40	7.83
Western States[2]	8.59	5.90
U.S. average	9.60	6.59
1961:		
Florida	9.93	6.88
Tennessee	11.85	8.21
Western States[2]	8.76	6.08
U.S. average	10.00	6.93
1962:		
Florida	9.61	6.78
Tennessee	11.37	8.02
Western States[2]	9.50	6.70
U.S. average	9.81	6.92
1963:		
Florida	9.65	6.91
Tennessee	10.50	7.52
Western States[2]	9.50	6.80
U.S. average	9.74	6.97
1964:		
Florida[3]	9.64	7.01
Tennessee	10.51	7.64
Western States[2]	8.77	6.38
U.S. average	9.61	6.99
1965:		
Florida[3]	9.71	7.22
Tennessee	11.19	8.32
Western States[2]	8.80	6.54
U.S. average	9.71	7.22
1966:		
Florida[3]	9.39	7.21
Tennessee	10.97	8.42
Western States[2]	9.91	7.61
U.S. average	9.60	7.37
1967:		
Florida[3]	9.08	7.18
Tennessee	10.52	8.31
Western States[2]	10.20	8.06
U.S. average	9.34	7.37
1968:		
Florida[3]	7.82	6.45
Tennessee	10.01	8.27
Western States[2]	8.90	7.34
U.S. average	8.11	6.70
1969:		
Florida[3]	6.82	5.92
Tennessee[4]	7.33	6.36
Western States[2]	8.16	7.08
U.S. average	7.03	6.10
1970:		
Florida[3]	6.13	5.60
Tennessee[4]	5.90	5.39
Western States[2]	8.08	7.39
U.S. average	6.34	5.79
1971:		
Florida[3]	6.00	5.75
Tennessee	5.43	5.21
Western States[2]	6.60	6.34
U.S. average	6.02	5.78
1972:		
Florida[3]	5.62	5.62
Tennessee	5.49	5.49
Western States[2]	5.63	5.63
U.S. average	5.61	5.61
1973:		
Florida[3]	5.81	6.14
Tennessee	5.40	5.71
Western States[2]	7.60	7.18
U.S. average	5.90	6.24
1974:		
Florida[3]	10.41	12.07
Tennessee	7.51	8.71
Western States[2]	11.48	13.32
U.S. average	10.43	12.10
1975:		
Florida[3]	21.21	26.96
Tennessee	10.84	13.78
Western States[2]	13.56	17.24
U.S. average	19.93	25.34
1976:		
Florida[3]	17.09	22.85
Tennessee	6.61	8.85
Western States[2]	10.24	13.69
U.S. average	15.88	21.25
1977:		
Florida[3]	13.81	19.55
Tennessee	6.35	8.99
Western States[2]	13.77	19.49
U.S. average	12.45	17.61
1978:		
Florida[3]	12.42	18.89
Tennessee	5.40	8.22
Western States[5]	12.66	19.25
U.S. average	12.20	18.56

[1] Constant dollar values have been rounded to nearest hundredth.
[2] Includes Arkansas (1963–66), California (1968–70), Idaho, Montana, Missouri (1973–77), Utah, and Wyoming.
[3] Includes North Carolina.
[4] Includes Alabama.
[5] Includes Alabama, Idaho, Montana, Utah, and Wyoming (1978).

tions as well as uses in the ceramics and chemical manufacturing industries. Recovery of fluosilicic acid from phosphoric acid plants in 1978 was estimated at 70,000 metric tons. At an average value of $80 per ton, this means that $5.6 million worth of fluosilicic acid was produced. In 1978 U.S. imports of fluorspar totaled 1.0 million metric tons, which represented about 80 percent of the Nation's fluorine requirements. This total would have been larger by a value of $5.6 million were it not for Florida's byproduct production of fluosilicic acid. Thus $5.6 million in byproduct fluosilicic acid production was a positive contribution to the U.S. balance of payments because this acid would have had to have been imported if it had not been produced domestically.

Impact on the Domestic Sulfur Industry

The Florida phosphatic fertilizer industry consumes about one-half of all U.S. sulfur production, in addition to its consumption of imported sulfur. In 1978 the State's phosphatic fertilizer industry consumed approximately 5.8 million metric tons of domestic sulfur, and it was estimated that in 1981 this consumption would reach a level of about 6.0 million metric tons. This means that at a sulfur price of $80 per ton, the Florida fertilizer industry would purchase $480 million of domestic sulfur in 1981.

Also, the Frasch sulfur industry, which mines sulfur using

Table 30.—Florida phosphate rock producers

Commodity, company, and address	Map reference number (as shown in figure 11)	Number of mines (all open pit)	County
LAND PEBBLE			
Agrico Chemical Co. Pierce, Fla. 33867	1, 3	3	Polk.
Bordon Chemical Co. Box 790 Plant City, Fla. 33566	4	1	Hillsborough.
Brewster Phosphate Co. Bradley, Fla. 33835	5	2	Do.
C. F. Industries, Inc. Box 1480 Bartow, Fla. 33830	14	1	Hardee.
Gardinier, Inc. Box 3269 Tampa, Fla. 33601	6	1	Polk.
International Minerals & Chemical Co. Box 867 Bartow, Fla. 33830	9, 11	3	Do.
Mobile Chemical Co. Box 311 Nichols, Fla. 33863	12, 13	2	Do.
Occidental Petroleum Corp., Suwannee River Phosphate Div. Box 300 White Springs, Fla. 32096	21, 22	2	Hamilton.
Swift Chemical Corp. Box 208 Bartow, Fla. 33830	13	2	Polk.
T. A. Minerals Corp. Pierce, Fla. 33867	16	1	Do.
U.S.S. Agri-Chemicals, Inc. Fort Mead, Fla. 33841	15	1	Do.
W. R. Grace & Co. Box 471 Bartow, Fla. 33830	7, 8	2	Do.
SOFT ROCK			
Howard Phosphate Co. Box 13800 Orlando, Fla. 32809	19, 20	1	Citrus.
Kellogg Co. Box 200 Hernando, Fla. 32642	17	1	Do.
Loncala Phosphate Co. Box 766 High Springs, Fla. 32643	23	1	Gilchrist, Marion.
Manko Co., Inc. Box 557 Ocala, Fla. 32670	18	1	Citrus.

a hot-water melting process, is heavily dependent on the Florida fertilizer industry.

Uranium Recovery from Wet-Process Phosphoric Acid

At the 1978 production cost of less than or equal to $16.50 per metric ton, phosphate rock reserves in the central Florida region were estimated to total 340 million metric tons. It has been estimated that these reserves contain between 0.01 and 0.02 percent uranium oxide (U_3O_8), which can be recovered as byproduct uranium from wet-process phosphoric acid plants. Several companies have shown interest in recovering this resource.

As is the case with any byproduct recovery, the potential U_3O_8 resources available as a byproduct of wet-process phosphoric acid are limited by the primary production schedule. This means that if the price of phosphate rock increases, the amount of available reserves will also increase with a potentially commensurate increase in U_3O_8 recovery, assuming that the then-available reserves contain economically recoverable U_3O_8. However, any delays in installing byproduct recovery plants would be expected to cause a corresponding loss in U_3O_8 resources.

Assuming a U_3O_8 content of 0.012 percent for all central Florida phosphate rock, total U_3O_8 reserves in the 340 million metric tons of rock would be 40,800 tons. At an overall recovery factor of 86 percent (95 percent from phosphoric acid production and 90 percent from the byproduct recovery plant), about 34,884 metric tons of U_3O_8 could be recovered from wet-process phosphoric acid at a production cost of about $20 per pound, including a 20-percent return on invested capital. This cost, which is substantially lower than the 1978 market price for U_3O_8 of more than $40 per pound, indicates the economic attractiveness of U_3O_8 byproduct production from wet-process phosphoric acid. The total value of potentially recoverable U_3O_8, assuming 34,884 metric tons of resources and a spot price at yearend 1977 of $42 per pound of U_3O_8, would be approximately $3.23 billion. If in 1981 the price of U_3O_8 is higher than the $42-per-pound price which has been estimated for that year, the value of this resource would rise accordingly. The technology for U_3O_8 recovery appears feasible, and the economic considerations make expanded commercialization of this uranium production an attractive prospect.

In 1976 Uranium Recovery Corp. (URC) installed a uranium recovery module at the W. R. Grace & Co. plant near Bartow, Fla. From this plant, concentrated stripped solution is shipped to URC's central processing plant near Mulberry, Fla., where yellowcake (certain uranium concentrates produced by mills) is recovered from the solution. Wyoming Mineral Corp., a subsidiary of Westinghouse Electric Corp., has constructed a uranium oxide recovery facility at Farmland Industries' phosphoric acid complex, also near Bartow. The facility went onstream in August 1978, and plans were to recover about 450,000 pounds of U_3O_8 per year.

Several additional companies announced plans in 1978 to recover U_3O_8 from wet-process phosphoric acid and to build recovery facilities. One of these, International Minerals and Chemicals Corp., planned to recover 1.2 million pounds of U_3O_8 annually from C.F. Industries' two wet-process phosphoric acid plants in Polk and Hillsborough Counties and an additional 600,000 pounds per year from its own New Wales chemical plant in Polk County.

Table 31.—Domestic phosphate rock consumers

Company	City and State	Map reference number (as shown in figure 12)	Products manufactured
Agrico-Chem-Williams	Pierce, Fla.	1	Wet-process phosphoric acid, ammonium phosphate.
Borden Chemical Co.	Piney Point, Fla.	2	Wet-process phosphoric acid, ammonium phosphate, concentrated superphosphate.
C. F. Industries Inc.	Bartow, Fla.	3	Do.
Englehard M&C-Con. Serve Inc.	Nichols, Fla.	4	Do.
Farmland Industries	Pierce, Fla.	5	Do.
Gardinier, Inc.	Tampa, Fla.	6	Do.
W. R. Grace & Co.	Bartow, Fla.	7	Do.
Homes	Pierce, Fla.	8	(Idle plant.)
International Minerals & Chemical Corp.	Bonnie, Fla.	9	Wet-process phosphoric acid, ammonium phosphate, concentrated superphosphate.
Mobil Chemical Co.	Nichols, Fla.	10	(Idle plant.)
C. F. Industries Inc.	Bonnie, Fla.	11	Wet-process phosphoric acid, ammonium phosphate.
Royster Co.	Mulberry, Fla.	12	Wet-process phosphoric acid, ammonium phosphate, concentrated superphosphate.
Stauffer Chemical Co.	Tarpon Springs, Fla.	13	(Idle plant.)
U.S.S. Agri-Chemicals	Ft. Meade, Fla.	14	Wet-process phosphoric acid, concentrated superphosphate.
U.S.S. Agri-Chemicals	Bartow, Fla.	15	Ammonium phosphate.
Occidental Agri-Chemicals	White Springs, Fla.	16	Wet-process phosphoric acid, ammonium phosphate, concentrated superphosphate.
Texasgulf Inc.	Lee Creek, N.C.	18	Do.
Stauffer Chemical Co.	Columbia, Tenn.	19	Elemental phosphorus.
Hooker Chemical Co.	Do.	20	Do.
Monsanto Industrial Chemicals Co.	Do.	21	Agricultural chemicals.
Tennessee Valley Authority	Muscle Shoals, Ala.	22	Elemental phosphorus.
U.S.S. Agri-Chemicals	Cherokee, Ala.	23	Ammonium phosphate.
Mississippi Chemical Corp.	Pascaquela, Miss.	24	Wet-process phosphoric acid, concentrated superphosphate.
Beker Industries Corp.	Taft, La.	26	Wet-process phosphoric acid, ammonium phosphate.
Allied Chemical Corp.	Geismar, La.	27	Do.
Freeport Minerals	Uncle Sam, La.	29	Wet-process phosphoric acid.
Gardinier, Inc.	Helena, Ark.	30	Do.
W. R. Grace & Co.	Joplin, Mo.	31	Concentrated superphosphate.
Farmland Industries	Do.	32	(Idle plant.)
First Mississippi Corp.	Ft. Madison, La.	33	Wet-process phosphoric acid, ammonium phosphate.
Beker Industries Corp.	Marseilles, Ill.	34	(Idle plant.)
Olin Corp.	Joliet, Ill.	35	Wet-process phosphoric acid.
Mobil Chemical Co.	Depue, Ill.	36	Wet-process phosphoric acid, ammonium phosphate.
Farmland Industries	Lawrence, Kans.	37	(Idle plant.)
Nipak, Inc.	Kerens, Tex.	38	Ammonium phosphate.
Olin Corp.	Pasadena, Tex.	39	Wet-process phosphoric acid, ammonium phosphate.
Phosphate Chemical	Do.	40	(Idle plant.)
El Paso Products	Odessa, Tex.	41	Do.
Valley Nitrate Producers	Chandler, Ariz.	42	Do.
Stauffer Chemical Co.	Garfield, Utah	43	Wet-process phosphoric acid, ammonium phosphate, concentrated superphosphate.
F.M.C. Corp.	Pocatello, Idaho	45	Elemental phosphorus.
Monsanto Industrial Chemicals Co.	Soda Springs, Idaho	46	Do.
J. R. Simplot	Pocatello, Idaho	47	Wet-process phosphoric acid, ammonium phosphate, concentrated superphosphate.
Beker Industries Corp.	Conda, Idaho	48	Do.
Gulf Resources	Kellogg, Idaho	49	Wet-process phosphoric acid, ammonium phosphate.
Stauffer Chemical Co.	Silver Bow, Mont.	50	Elemental phosphorus.
Duval Corp.	Hanford, Calif.	51	Wet-process phosphoric acid.
Kaiser Steel	Fontana, Calif.	52	(Idle plant.)
Collier Carbon & Chemical	Pittsburg, Calif.	53	Wet-process phosphoric acid.
Agrico Chem-Williams	Donaldsville, La.	([1])	Wet-process phosphoric acid, ammonium phosphate.
Borden Chemical Co.	Streator, Ill.	([1])	Wet-process phosphoric acid.
C.F. Industries Inc.	Hardee City, Fla.	([1])	Do.[2]
Grace and U.S.S. Agri-Chemicals	Bartow, Fla.	([1])	Wet-process phosphoric acid.[3]
Occidental Agricultural Chemical Co.	Lathrop, Calif.	([1])	Wet-process phosphoric acid.
Valley Nitrogen Products	Helm, Calif.	([1])	Wet-process phosphoric acid, ammonium phosphate.
Do.	Bena, Calif.	([1])	Wet-process phosphoric acid.

[1] Recent additions to this table; not shown on map in figure 12.
[2] Plant planned.
[3] Plant under construction.

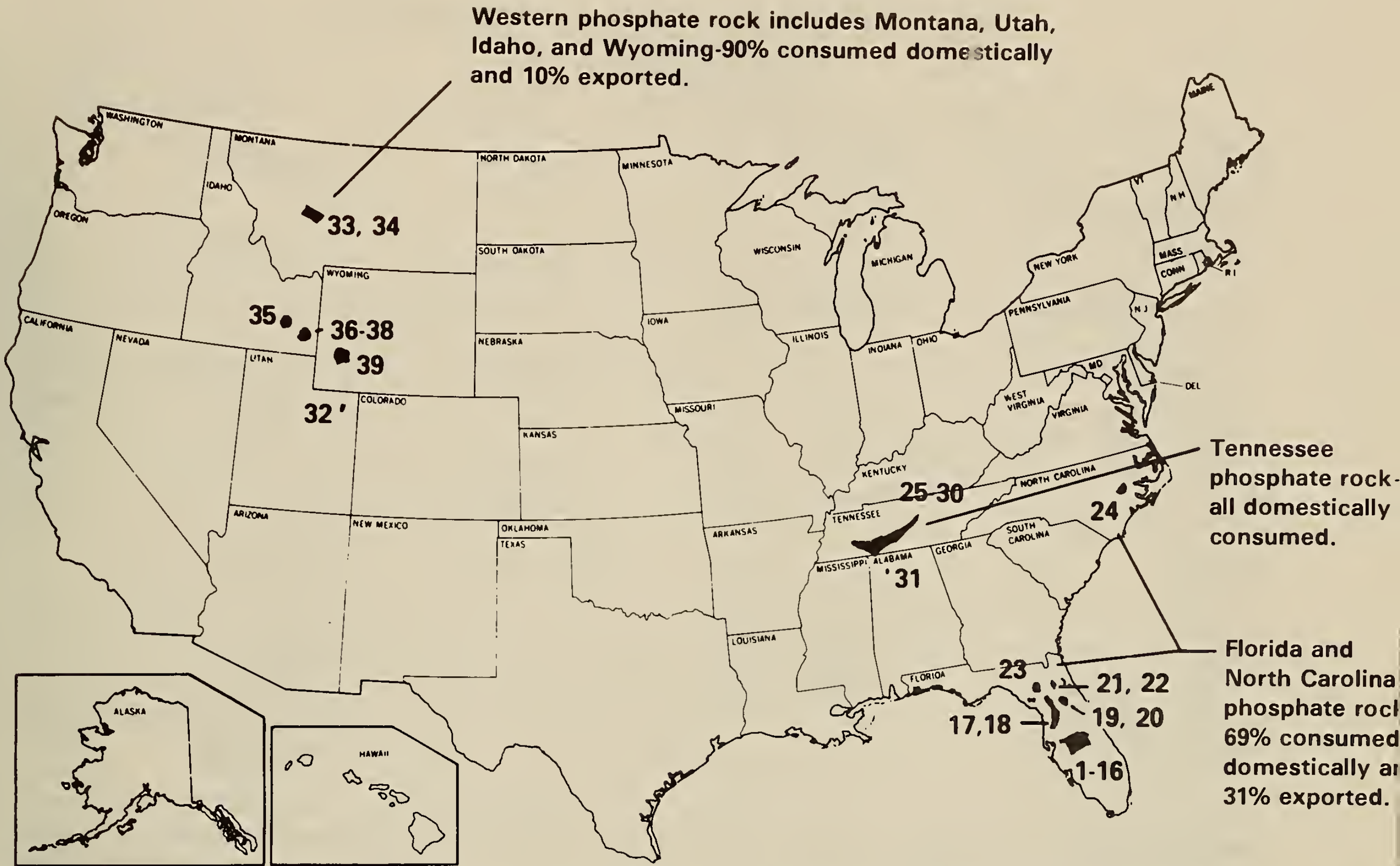


Figure 11.—Location of phosphate rock production (blackened areas) in the United States, 1977. (Reference numbers, identified in table 30 and 33, indicate locations of individual phosphate rock producers.)

Table 32.—Phophate fertilizer production capacity in Florida, 1978

(Thousand metric tons P_2O_5)

Company	Plant location	Phosphoric acid, wet-process	Ammonium phosphate	Concentrated superphosphate
Agrico Chemical-Williams	Pierce, Fla.	247	75	250
Borden Chemical Co.	Piney Point, Fla.	159	77	30
C. F. Industries Inc.	Bonnie, Fla.	626	576	NAp
Do.	Plant City, Fla.	567	249	340
Engelhard M & C-Con. Serve Inc.	Nichols, Fla.	136	109	117
Farmland Industries	Pierce, Fla.	413	163	79
Gardinier, Inc.	Tampa, Fla.	494	227	340
Grace & U.S.S. Agri-Chemicals, Inc.	Bartow, Fla.	345	NAp	NAp
W. R. Grace & Co.	Do.	299	95	290
International Minerals & Chemical Co.	Bonnie, Fla.	680	227	125
Occidental Agricultural Chemical Co.	White Springs, Fla.	526	275	71
Royster Co.	Mulberry, Fla.	122	73	88
U.S.S. Agri-Chemicals, Inc.	Bartow, Fla.	NAp	125	NAp
Do.	Fort Meade, Fla.	160	NAp	110
Total		4,799	2,272	1,841

NAp Not applicable.

Source: National Fertilizer Development Center (*13*).

Table 33.—Phosphate rock producers in States other than Florida

State, company, and address	Map reference number for production location (as shown in figure 11)	Type of activity	Production location, county
Alabama:			
Monsanto Industrial Chemical Co. Box 5523 Denver, Colo. 80217	31	1 open pit mine	Limestone, Ala.
Idaho:			
Conda Partnership Box 37 Conda, Idaho 83230	36	do	Caribou, Idaho.
Monsanto Industrial Chemical Co. Box 816 Soda Springs, Idaho 83276	37	do	Do.
J. R. Simplot Co., Fertilizer Div. Box 912 Pocatello, Idaho 83201	35	2 open pit mines	Bingham and Caribou.
Stauffer Chemical Co. Star Route Randolph, Utah 84064	38	1 open pit mine	Caribou, Idaho
Montana:			
Cominco American, Inc. Garrison, Mont. 59731	33, 34	2 underground mines	Powell.
North Carolina:			
Texasgulf, Inc. Box 48 Aurora, N.C. 27806	24	1 open pit mine	Beaufort, N.C.
Tennessee:			
Hooker Chemical Co. Box 591 Columbia, Tenn. 38401	25, 26	Open pit mines	Hickman, Tenn.
Monsanto Industrial Chemical Co. Columbia, Tenn. 38401	27-29	do	Giles, Hickman, Maury, and Williamson, Tenn.
Stauffer Chemical Co. Mt. Pleasant, Tenn. 38474	30	do	Maury, Tenn.
Utah:			
Stauffer Chemical Co. Manila Star Route Vernal, Utah 84078	32	1 open pit mine	Uintah, Utah

Table 34.—U.S. phosphate rock production, consumption, sales, and exports; and world production

	1973	1974	1975	1976	1977	1978
United States:						
Mine production thousand metric tons	126,746	141,382	170,112	154,309	166,893	173,429
Marketable production do	38,226	41,446	44,285	44,671	47,256	50,037
Value thousands	$238,667	$501,429	$1,122,184	$949,365	$821,657	$928,820
Average value per metric ton	$6.24	$12.10	$25.34	$21.25	$17.39	$18.56
Sold or used by producers thousand metric tons	40,862	43,940	42,129	40,530	47,437	48,774
Value thousands	$254,846	$529,141	$1,052,995	$857,189	$829,084	$901,378
Average value per metric ton	$6.24	$12.04	$24.99	$21.15	$17.48	$18.56
Imports for consumption [1] thousand metric tons	59	165	35	46	158	908
Value thousands	$1,288	$8,999	$1,604	$2,209	$6,079	$24,379
Average value per metric ton	$21.85	$54.51	$48.31	$52.60	$38.47	$26.85
Exports [2] thousand metric tons	12,587	12,607	11,133	9,453	13,230	[r] 12,870
P_2O_5 content do	4,084	4,053	3,588	3,023	4,251	[r] 4,118
Value thousands	$82,983	$194,015	$429,222	$272,823	$288,603	$297,357
Average value per metric ton	$6.59	$15.39	$38.56	$28.91	$21.81	$23.10
Consumption, apparent [3] thousand metric tons	28,334	31,497	31,028	31,142	34,365	[r] 36,812
World: Production do	98,723	109,987	107,278	107,616	116,000	125,000

[r] Revised.
[1] U.S. Department of Commerce, Bureau of the Census data.
[2] Exports as reported by companies to the Bureau of Mines.
[3] Quantity sold or used by producers plus imports minus exports.

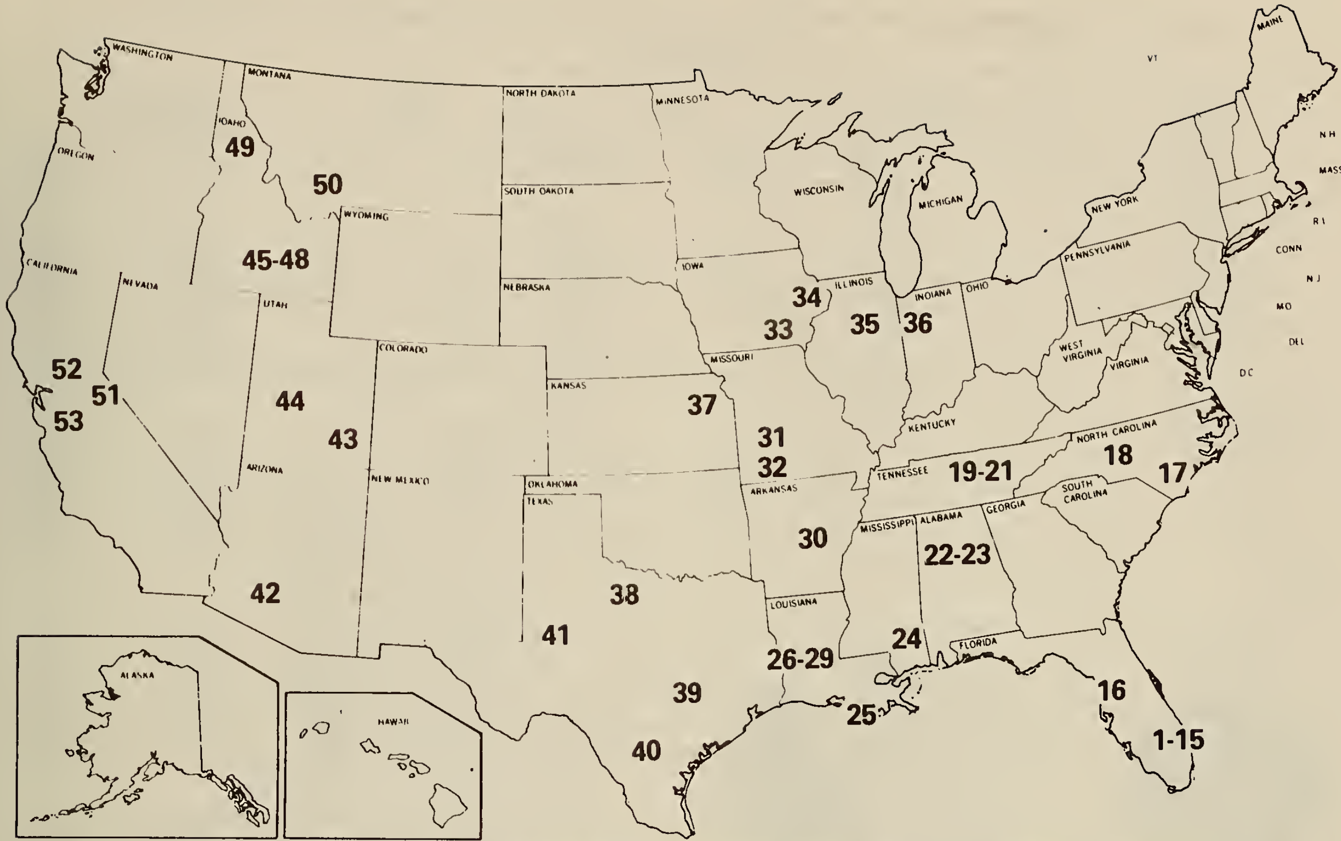


Figure 12.—Location of phosphate rock consumers in the United States, 1977. (Companies corresponding to map reference numbers are listed in table 31.)

Byproduct Fluorine Production

Fluorine is principally recovered from the mineral fluorite, commonly known as fluorspar. At extrapolated rates of consumption, all known fluorspar deposits in the world are expected to be depleted before the end of the century. In that event, the world's fluorine supply would have to be derived from newly discovered deposits or from phosphate rock. It has been estimated that fluorine resources in phosphate rock are adequate to satisfy world demand well into the next century (*18*).

Fluorine is necessary to produce aluminum, steel, and many chemical compounds. Fluorine demand more than doubled during the 1960–70 period, reflecting strong growth in the aluminum, chemical, and steel sectors. In 1976 the aluminum industry accounted for 20.2 percent of U.S. fluorine consumption, or 102,512 metric tons. Consumption by the fluorcarbon industry is difficult to estimate because of a scarcity of data. Practically all fluorine usage is in the form of acid, metallurgical, and ceramic grades of fluorspar.

In 1978 the United States produced about 20 percent of its fluorine requirements and 5 percent of world production. It consumed about 30 percent of the world supply. Apparent U.S. consumption was approximately 550,000 metric tons in 1978 and is forecast to be 3.5 times this quantity, or 1.65 million metric tons, in the year 2000. A straight-line projection of domestic production over the last 20 years indicates that only about 137,892 metric tons will be produced in the year 2000. However, it is expected that imports and the domestic recovery of fluorine from phosphatic fertilizer production will make up for the apparent difference between domestic consumption and production for the year 2000.

The largest known source of fluorine in the United States is in phosphate rock deposits. Florida phosphate rock contains from 3 to 4 percent fluorine. Recovery of fluorine from

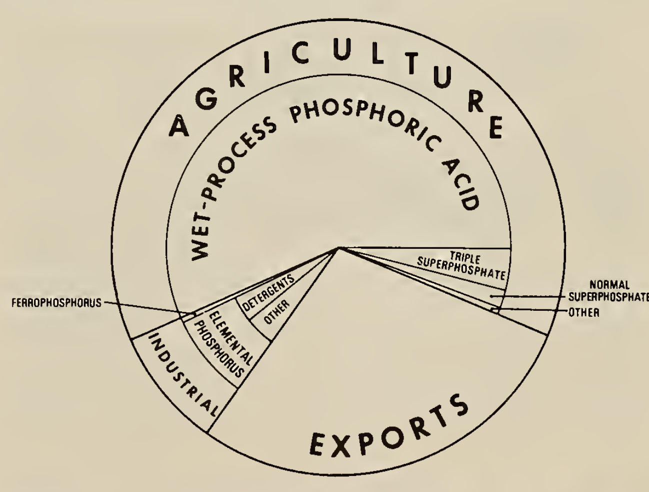


Figure 13.—Generalized U.S. phosphate rock use pattern.

Table 35.—Phosphate rock sold or used by producers, by use and by geographic area, 1973–78

(Thousand metric tons)

Year and use	Florida and North Carolina		Tennessee		Western States		Total United States [1]	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1973:								
Domestic:								
Agricultural	21,501	6,732	14	4	1,531	494	23,046	7,229
Industrial	W	W	2,403	630	W	W	5,229	1,362
Total	21,501	6,732	2,418	634	1,531	494	28,275	8,591
Exports [1]	W	W	0	0	W	W	12,587	4,084
Total [2]	33,490	10,632	2,418	634	4,955	1,408	40,862	12,675
1974:								
Domestic:								
Agricultural	24,150	7,504	0	0	1,806	580	25,956	8,084
Industrial	W	W	2,365	642	W	W	5,376	1,422
Total	24,150	7,504	2,365	642	1,806	580	31,322	9,505
Exports [1]	W	W	0	0	W	W	12,607	4,053
Total [2]	36,215	11,390	2,365	642	5,360	1,527	43,940	13,559
1975:								
Domestic:								
Agricultural	23,947	7,411	0	0	1,902	608	25,849	8,018
Industrial	354	104	2,171	560	2,622	676	5,146	1,340
Total	24,301	7,515	2,171	560	4,524	1,283	30,996	9,358
Exports [1]	10,102	3,275	0	0	1,031	313	11,133	3,588
Total [2]	34,401	10,790	2,171	560	5,556	1,597	42,129	12,946
1976:								
Domestic:								
Agricultural	24,729	7,631	0	0	1,651	524	26,380	8,156
Industrial	409	120	1,731	448	2,575	661	4,716	1,229
Total	25,138	7,750	1,731	448	4,227	1,187	31,096	9,385
Exports [1]	8,783	2,825	0	0	651	197	9,435	3,023
Total [2]	33,921	10,576	1,731	448	4,878	1,383	40,530	12,408
1977:								
Domestic:								
Agricultural	27,901	8,637	0	0	2,222	716	30,123	9,353
Industrial	334	98	1,723	436	2,026	523	4,084	1,056
Total	28,235	8,735	1,723	436	4,248	1,239	34,207	10,409
Exports [1]	12,759	4,108	0	0	471	143	13,230	4,251
Total [2]	40,994	12,843	1,723	436	4,719	1,382	47,437	14,660
1978:								
Domestic:								
Agricultural	[r] 29,314	[r] 8,998	0	0	2,018	646	[r] 31,332	[r] 9,644
Industrial	291	84	1,688	434	2,592	668	4,571	1,186
Total [2]	[r] 29,605	[r] 9,082	1,688	434	4,611	1,314	[r] 35,904	[r] 10,830
Exports [1]	[r] 11,810	[r] 3,785	0	0	1,060	333	[r] 12,870	[r] 4,118
Total [2]	41,415	12,867	1,688	434	5,671	1,647	48,774	14,948

[r] Revised. W Withheld to avoid disclosing company proprietary data.
[1] Exports as reported by companies to the Bureau of Mines.
[2] Data may not add to totals shown because of independent rounding.

Table 36.—U.S. exports of phosphate products and phosphate rock equivalence, 1978[1]

(Metric tons)

Product	Quantity exported	P_2O_5 content	Mined rock equivalent
Phosphate, crude apatite	13,692,603	4,244,707	13,692,603
Diammonium phosphate	3,929,076	1,807,375	6,679,429
Phosphoric acid, fertilizer grade	1,523,161	822,507	2,894,006
Triple superphosphate	1,462,002	672,521	2,339,203
Ammonium phosphate	459,278	101,041	321,495
Mixed chemical fertilizer	198,674	29,801	99,337
Calcium phosphate	117,509	23,502	82,256
Phosphoric acid, thermal grade	88,759	62,131	204,146
Sodium tripolyphosphate	43,987	4,839	17,595
Normal superphosphate	32,144	6,429	22,501
Phosphate chemical fertilizer	25,269	7,581	25,269
Other sodium phosphates	23,021	3,453	11,511
Elemental phosphorus	20,580	47,157	185,220
Total	21,616,063	7,833,044	26,574,561

[1] Data from the U.S. Department of Commerce, Bureau of the Census (*31*), adjusted by the Bureau of Mines.

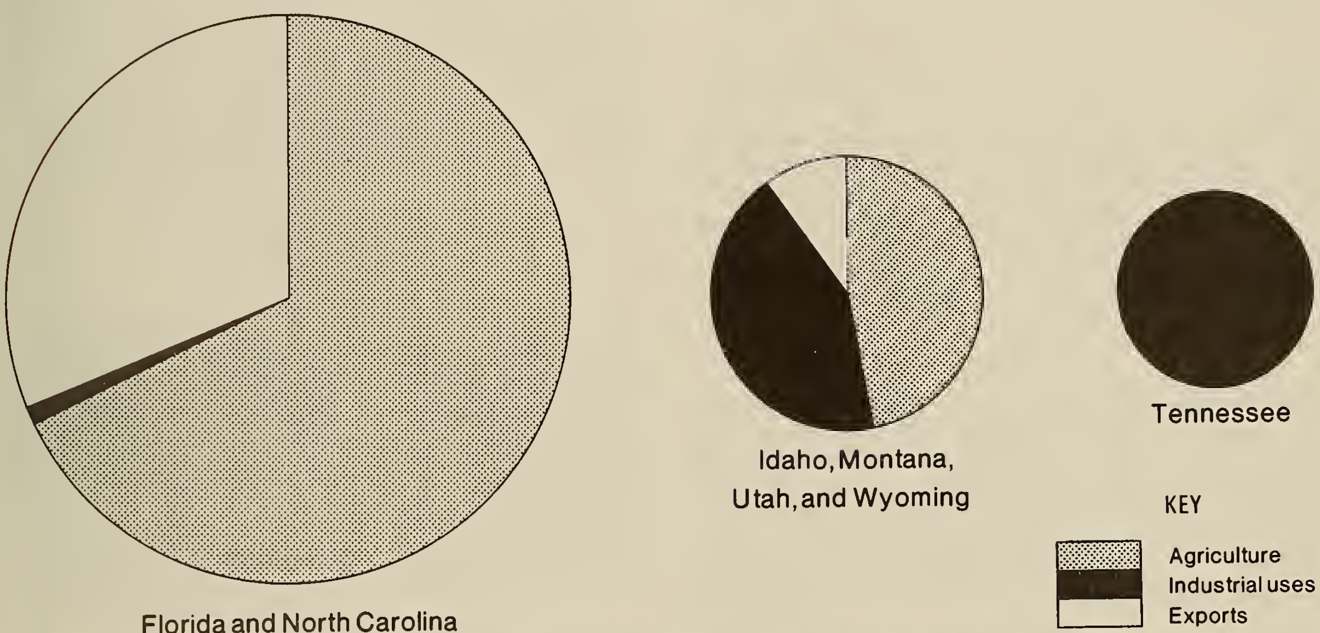


Figure 14.—Phosphate rock sold or used by producers, by use and by geographic area, 1977.

Table 37.—Projected income, employment, and output value for the Florida phosphate industry in 1981

	Florida	Rest of Nation	National total
Output value, million 1977 dollars:			
Direct	870	405	1,275
Indirect	490	1,000	1,490
Total	1,360	1,405	2,765
Employment, number of jobs:			
Direct	12,554	NAp	12,554
Indirect	10,331	15,478	25,809
Induced	25,614	44,900	70,514
Total	48,499	60,378	108,877
Income, million 1977 dollars:			
Direct	167.3	NAp	167.3
Indirect	105.8	98.8	204.6
Induced	174.4	292.3	466.7
Total	447.5	391.0	838.5

NAp Not applicable.

Table 38.—State, local, and Federal tax revenues associated with the Florida phosphate industry, projections for 1981

(Million 1977 dollars)

Tax	Florida	Rest of Nation	National total
Federal and State personal income tax	NAp	60.0	60.0
Federal corporate income tax	NAp	122.6	122.6
Florida corporate income tax	5.8	NAp	5.8
Florida severance tax	48.5	NAp	48.5
Florida motor fuel tax	.3	NAp	.3
State sales taxes	25.0	4.4	29.4
Local property taxes	20.0	30.0	50.0
Total	99.6	217.0	316.6

NAp Not applicable.

phosphatic fertilizer operations was not economic in the past, but because of recent, relatively high, stable prices, fluorine is now economically recovered from wet-process phosphoric acid plants. Also, as a result of a U.S. Environmental Protection Agency promulgation, this recovery is now required by law. Two large fertilizer producers in Florida, United States Steel Corp's. Agri-Chemical Div. and Farmland Industries, are supplying fluosilicic acid, a former waste product, to Aluminum Can Co. of America (Alcoa) and Kaiser Aluminum and Chemical Corp. for the manufacture of synthetic cryolite and aluminum fluoride. In addition, 12 phosphoric acid plants supplemented domestic supplies of fluorine with about 54,431 metric tons of fluosilicic acid in 1977, or the equivalent of about 90,718 metric tons of fluorspar.

Fluosilicic acid production from Florida is expected to reach 70,000 tons per year by 1985. Therefore, based on a value of $100 per ton of fluosilicic acid and assuming the productive life of the State's phosphate rock deposits to be at least 20 years, Florida's total byproduct fluosilicic acid production would have a value of $140 million (in constant 1977 dollars) in 2005.

IMPORTANCE OF PHOSPHATE FERTILIZER TO THE AGRICULTURAL SECTOR

Phosphate fertilizers are derived from the mining and treatment of phosphate rock. Treatment of the phosphate rock makes the phosphate soluble and available to growing plants. Phosphorus is required by all living plant and animal cells. Consequently, soils with deficiencies of available phosphorus produce only limited crop yields. Although it is not required in large amounts, the absence or near absence of phosphorus is calamitous to crop growth. A handbook published by the fertilizer industry (*10*) states that phosphorus "*must* be present in adequate amounts in living cells before cell division will take place . . . It also has many vital functions in photosynthesis utilization of both sugar and starches, and in energy transfer processes."

Because phosphorus is depleted from the soil as agricultural production continues, a like amount must be returned to the soil in order to maintain an acceptable level of productivity. Phosphate fertilizer must be used to replenish the level of phosphorus pentoxide (P_2O_5) in the soil since there is *no substitute* for phosphorus as a plant nutrient, and substantial quantities of soluble phosphorus are derived only from phosphate rock. Approximately 88 percent of all phosphate rock consumed in the United States is utilized in the production of phosphate fertilizer.

Use in Agriculture

Of the phosphate rock mined in Florida that is not shipped directly to export markets, more than 95 percent is used to produce agricultural chemicals, that is, fertilizers or animal feed supplements. Historically, four major crops have accounted for approximately 62 percent of U.S. phosphatic fertilizer consumption; these crops are corn for grain,[12] cotton, soybean for beans,[12] and wheat. The use of phosphatic fertilizer for oats, barley, hay, and pasture accounts for another 20 percent of U.S. consumption. The Corn Belt States are by far the largest consumers of phosphatic fertilizer in the United States, as previously shown in figure 7.

CORN FOR GRAIN

The single largest use of fertilizer in the United States is for growing corn. Almost 68 million acres of corn for grain was harvested in the United States in 1978. Approximately 39 percent of the P_2O_5 used in the United States in the 1978 fertilizer year was used to produce corn for grain.

In 1978 the U.S. Department of Agriculture (USDA) surveyed 17 States to collect data on fertilizer use for corn crops. The survey accounted for 91 percent of the total acreage of corn harvested for grain in the United States. Of the fields surveyed in 1978, a total of 95 percent received some fertilizer; the previous year's total was 96 percent. The proportion of corn acreage receiving P_2O_5 remained steady from 1977 to 1978, at 87 percent.

[12] Category used by the U.S. Department of Agriculture for the collection of data pertaining to fertilizer use. Corn for grain, which accounts for 90 percent of all corn grown, is harvested only for the corn kernel, as opposed to corn for silage, which is harvested for use of the entire corn plant as feed. Although soybean is now grown exclusively for its bean, historically this has not always been the case.

COTTON

Eleven cotton producing States were surveyed by USDA for data on fertilizer use in 1978, and these 11 States accounted for 98 percent of the total U.S. cotton acreage that was harvested that year. Of the fields surveyed, 69 percent received some fertilizer, which was down substantially from the previous year's total. Harvested acreage that received phosphate declined about 10 percent from 1977 to 1978. Application rates were also lower; in 1978 the average rate was approximately 45 pounds of P_2O_5 per acre of cotton.

Nearly all fields harvested for cotton in the Southern States, where intensive cultivation over the years has depleted the soil of its natural nutrients, received some fertilizer in 1978. In Texas and Oklahoma, however, where insufficient moisture is a threat, only half the cotton acreage was fertilized.

SOYBEANS FOR BEANS

Sixteen States surveyed by USDA for fertilizer use on soybeans for beans in 1978 accounted for 91 percent of the harvested soybean acreage in the United States. Harvested acreage receiving some fertilizer remained stable at about 37 percent in 1977 and 1978. The proportion of soybean acreage receiving phosphate fertilizer was stable at about 36 percent during the same period. Application rates for P_2O_5 averaged 45 pounds per acre in 1978, which was up slightly compared with application rates for recent years.

WHEAT

Seventeen States were surveyed by USDA for fertilizer use on wheat in 1978, and these 17 States accounted for 92 percent of the total acreage harvested for wheat in the United States that year. Of the fields surveyed, 61 percent received some fertilizer, compared with 65 percent in 1977. The proportion of acreage receiving phosphate decreased in 1978. Applications rates on harvested acreage also decreased, from 36 pounds of P_2O_5 per acre in 1977 to 35 pounds per acre in 1978 (*33*).

U.S. Balance of Trade

In 1977 the U.S. balance of trade showed a deficit of $26.5 billion. Imports of petroleum and petroleum products, valued at $41.5 billion, were largely responsible for this deficit, and the value of these imports is rapidly increasing as the world price of petroleum continues to rise. In recent years, however, gross agricultural exports have also risen steadily, from $17.7 billion in 1973 to a record $23.7 billion in 1977 (table 39). With imports of agricultural products in the same year valued at $13.5 billion, the U.S. agricultural sector maintained a net positive balance of trade of $10.2 billion (*35*). The positive contribution of agricultural exports to the U.S. balance of payments is growing and is expected to continue to grow in the foreseeable future.

One reason for this growth is grain imports by the U.S.S.R. In 1976 the U.S.S.R. agreed to purchase at least 6 million metric tons of grain per year from the United States, with any purchases beyond 8 million metric tons per year to require further negotiation. In 1977 the ceiling for these purchases

Table 39.—U.S. foreign trade in agricultural products

(Billions)

Year	Exports	Imports	Balance
1958	$3.9	$3.9	$0
1959	4.0	4.1	−0.1
1960	4.9	3.8	1.1
1961	5.0	3.7	1.3
1962	5.0	3.9	1.1
1963	5.6	4.0	1.6
1964	6.3	4.1	2.2
1965	6.2	4.1	2.1
1966	6.9	4.5	2.4
1967	6.4	4.5	1.9
1968	6.2	5.1	1.1
1969	5.9	5.1	.8
1970	7.2	5.8	1.4
1971	7.7	5.8	1.9
1972	9.4	6.5	2.9
1973	17.7	8.4	9.2
1974	22.0	10.4	11.6
1975	21.9	9.5	12.4
1976	23.0	11.2	11.8
1977	23.7	13.5	10.2

Source: International Economic Report of the President, January 1977 (*21*).

was raised to 15 million metric tons per year. In that year the Soviets bought 12.7 million metric tons of U.S. grain (9.3 million tons of corn and 3.4 million tons of wheat) valued at more than $1.3 billion. It was estimated that these figures doubled for 1978. Recent international developments have affected this trade, however, and it is unlikely in the short run that the United States will continue to export grain to the U.S.S.R.

As a result of the United States' formal recognition of Mainland China, an agricultural products market is likely to open up in that country.

A summary of the value of U.S. exports of four leading crops that received phosphatic fertilizers—corn, wheat, soybeans, and cotton—is given in table 40 for the 1977 crop year. The importance of phosphatic fertilizers to the domestic economy and to the U.S. balance of payments is evident from this table. Table 40 also shows that phosphatic fertilizers were a necessary input for $20.5 billion worth of domestic crops, including $6.1 billion worth of crop exports, with both of these figures including only the four crops listed above. Thus, when the value of crops grown using phosphatic fertilizers is taken into account, the importance of the phosphate industry is seen to be far greater than it appears when only the value of phosphate rock and fertilizer products is considered.

In the past, extensive research has been devoted to the importance of fertilizer to crop yield. It is held by many people that plant nutrients in fertilizers can be credited with more than one-third of the food production in the United States (*1*). Over the past 10 years the soil of farm lands throughout the

Table 41.—Phosphorus pentoxide (P_2O_5) taken up by various crops, 1976

Crop	Amount of P_2O_5 applied, pounds per acre	Approximate amount of P_2O_5 taken up by crop, pounds per acre	Average yield, bushels per acre
Corn	59.8	33.0	87.4
Wheat	18.6	16.7	30.3
Cotton	27.7	12.0	[1] 464.0
Soybeans	11.9	20.4	25.6

[1] Pounds per acre.

United States has been intensively fertilized. As a result, a certain amount of nutrient buildup is present in the soil. Because of this, the marginal yield of additional nutrient application may be low in the short run, for some crops. This is true regarding application of phosphate fertilizer.

One characteristic important to the analysis of phosphate fertilizer yield is the residual value from applied phosphate. In any one year, probably not more than 20 percent of the phosphorous added to the soil is taken up by the crop; therefore, a large percentage of phosphorus remains in the soil which can be used by future crops. Table 41 shows the approximate P_2O_5 content, in pounds per acre, of the 1976 yield of crops as harvested from the field. As shown in the table, much more P_2O_5 was applied to corn and cotton than was taken up by these crops. Soybeans, however, took up more P_2O_5 than was applied. This is because soybeans are commonly grown after corn on the same land, so soybean crops generally benefit from P_2O_5 that has been previously applied for corn. Because of this, a low percentage of soybean acreage is fertilized (28 percent in 1976). The data presented in the table imply that the extra P_2O_5 applied to the corn crop was utilized to a large degree by soybeans.

General advances in farm technology are expected to continue to increase crop yield responses to phosphatic fertilizers. It has been estimated that farmers receive a return of about $2.00 for every $1.00 spent for phosphatic fertilizers. In 1978 a total of 5.1 million tons of P_2O_5 was used in the United States (*2*). With P_2O_5 valued at 17 cents per pound, or $340 per ton, the cost of this P_2O_5 was about $1.7 billion.

In recent years fertilizer has become a growing input into current farm operating expenses. Fertilizer comprised 6 percent of current farm operating expenses in 1960, almost 8 percent of these expenses in 1965, and 12 percent in 1975. Thus, the percentage of current farm operating expenses that was spent on fertilizer increased by 100 percent in 15 years. Total current farm operating expenses increased 270 percent from 1960 to 1977; during this same period, fertilizer ex-

Table 40.—Value of crop production and exports in the 1977 crop year[1]

Crop	Value of U.S. production billions	Crop fertilized with phosphatic fertilizer, percent of total	Value of U.S. crop fertilized with phosphatic fertilizer, billions	Value of U.S. exports, billions	Value of U.S. exports fertilized with phosphatic fertilizer, billions
Corn	$14.7	90	$13.3	$3.6	$3.3
Wheat	6.2	50	3.1	2.0	1.0
Soybeans	8.5	28	2.4	3.8	1.1
Cotton	3.3	53	1.7	1.3	.7
Total	32.7	NAp	20.5	10.7	6.1

NAp Not applicable.

[1] Bureau of Mines, estimates based on U.S. Department of Agriculture preliminary information.

penses increased almost fivefold, from $1.3 billion to $5.9 billion. About $1.7 billion of the fertilizer expense for 1977 was for phosphate fertilizer (*32*).

U.S. Exports of Phosphatic Fertilizers

The United States is a major world supplier of phosphate fertilizers. In the 1977–78 fertilizer year, the United States exported nearly 7.3 million metric tons of P_2O_5 in various phosphate materials, equivalent to roughly one-fourth of the total U.S. production.

The five major importers of U.S. ammonium phosphate in 1977–78 were Brazil, India, Italy, Belgium, and France. Together these five countries received 69 percent of total U.S. imports. Indonesia, a major importer of U.S. ammonium phosphates in 1974–75, purchased none in 1975–76 because it had large domestic inventories. Pakistan, which imported only 12,000 metric tons of U.S. ammonium phosphates in 1974–75, became a relatively large importer in 1975–76, when it received 184,000 metric tons.

Eight nations imported 50,000 metric tons or more each of concentrated superphosphate from U.S. sources in 1977–78. The top four importing nations—Brazil, the Federal Republic of Germany, Indonesia, and Belgium—received two-thirds of total U.S. exports.

World Fertilizer Situation Review and Prospects

In the year ending June 30, 1975, the world fertilizer market emerged from 24 months of short supplies and high prices. In January 1975, international prices for fertilizers were at high levels. New plant capacity had been insufficient to meet the increased demand for fertilizer which resulted from panic buying, widespread crop shortfalls, record high grain prices, and international projections indicating continued fertilizer shortages and rising prices. High prices for fertilizer and expectations of lower crop prices reduced world demand, causing inventory buildups in both importing and exporting nations. World fertilizer prices then experienced a long decline from the unsustainable high levels of 1974–1975 until they hit bottom during 1976–77. In 1977–78 seasonal fluctuations continued for the major fertilizer components (*33*). Prices showed more strength and stability in the 1977–78 fertilizer year than they had in previous years.

It is expected that world demand for fertilizers will increase over the next few years, but the extent of the increase is uncertain (*33*). World production capacity for phosphate is expanding, and fertilizer inventories remain high in several major fertilizer importing countries. A recurrence of tight world market conditions for fertilizers seems unlikely through 1980–81. The world market for phosphate fertilizers is strong.

Phosphate Fertilizer Outlook

In 1975 the future of the phosphate fertilizer industry did not look good. Domestic demand had fallen back sharply from 1974 to 1975, and there were rumors that the U.S. export market was shattered. At the same time, the Nation's producers were in the midst of a 30-percent expansion that increased wet-process phosphoric acid capacity from 6.0 million metric tons per year in 1974 to 7.7 million metric tons per year in 1975. A glut of capacity was evident, but it was short-lived.

In 1977 the export market for phosphate fertilizer made large advances. Net export levels had almost doubled since 1974, and it appeared that the market had bounced back from the low level of 1974. Annual capacity in 1977 and 1978 was 8.8 and 9.3 million metric tons, respectively, and was projected to remain at 9.3 million metric tons through 1980, according to U.S. Department of Agriculture estimates. If demand increases, further expansion of phosphate fertilizer capacity will be needed by the early 1980's to replace obsolete plants and supply even larger amounts of wet-process phosphoric acid.

Export markets for phosphate products have been stable. Phosphate rock exports have declined in recent years, but exports of manufactured phosphate fertilizer have grown considerably in terms of P_2O_5 equivalent; the United States is now exporting more "value-added" materials along with its phosphate rock. Diammonium phosphate exports increased significantly in 1978, and other important phosphate products which showed export gains were concentrated superphosphate and phosphoric acid.

World consumption of manufactured phosphate fertilizers rose 4 percent in 1975–76 to an estimated 26.2 million tons of P_2O_5, after a drop of almost 7 percent during the previous year. Prices during 1975–76 declined, returning to early 1973 levels. Recent estimates put 1976–77 world phosphate consumption at approximately 28 million metric tons of P_2O_5 and 1978–79 consumption at close to 30 million metric tons. The developed countries were expected to account for about 50 percent of the 1976–77 world consumption of phosphate fertilizers, the centrally planned nations were expected to consume about 33 percent, and the developing countries about 17 percent (*34*). These proportions are expected to remain roughly constant through 1980–81.

The world produced 27.3 million metric tons of phosphate fertilizer in 1977 and consumed 26.5 million metric tons. It was projected in 1979 that world phosphoric acid capacity between 1977 and 1985 would increase by 30 percent. It was also projected that potential world production of phosphate fertilizers could reach 38.9 million metric tons by 1985 and that world consumption would reach 36.7 million metric tons. Based on these projections, world production can be expected to exceed world consumption by about 2.2 million metric tons in 1985. This excess would be equivalent to about 6 percent of production. During the past 10 years, world production has exceeded consumption by about 5 percent (*15*).

WORLD PRODUCTION AND CAPACITY OF PHOSPHATE ROCK

World Production

World phosphate rock production (fig. 15 and table 42) increased by 8 percent from 1973 to 1977, reaching a level of 116 million metric tons in 1977. The increase in demand for phosphate rock was even more substantial, although an oversupply persisted in 1976 and 1977. The increased demand was not sufficient, however, to eliminate a buyers' market that had prevailed since 1975.

By 1977 it was clear that any attempts by Morocco and other African and Near Eastern suppliers to establish a cartel would be unsuccessful. Phosphate rock prices for the 1978 contract year showed only a marginal improvement over the prices that had prevailed in 1977, and it appeared that any attempts by exporters to cover the costs of inflation were fragmentary, at best.

World Capacity

At the time this report was written (1980), it appeared that total world phosphate rock capacity for 1980 would be more than sufficient to meet the total world demand for that year. World capacity was estimated at 164 million metric tons for 1980, which was nearly 22 percent more than the 1977 world capacity of 134 million metric tons. This increase of nearly 22 percent implies an average annual growth rate of 7 percent. Continued capacity growth at this rate would be more than sufficient to meet the estimated growth in world demand for phosphate rock during the 1977–85 period; the probable average annual rate of demand growth for this period has been projected at 5.6 percent (2.5 percent for the United States and 5.1 percent for the rest of the world)(*20*).

This situation relates directly to the Florida phosphate industry and its future prospects. The industry has a secure domestic market, and growing world demand and higher prices can be expected to encourage more shipments into the export market. With two strong and growing markets available, the Florida phosphate industry has flexibility should one market weaken. The rest of the U.S. phosphate industry, however, will be at a disadvantage because freight rates have doubled since 1974, and the price of sulfur is at an alltime high.

The existing relationship between world capacity for phosphate rock and world demand—which will be growing by at least 5 percent per year in the mid-1980's, according to a World Bank forecast—depends directly upon the availability of sources of supply alternative to Florida. In 1977 Florida and North Carolina produced more than 40 million metric tons of phosphate rock, the equivalent of one-third of world production (table 42); it is estimated that in 1981 production for Florida alone will increase to 43 million metric tons. Although there are substantial phosphate rock reserves outside the United States (table 43), these reserves would require time and money for development. In order to develop new capacity equal to that which could be lost due to depletion of reserves in Florida, several years and new investment would be required. One certain consequence of a reduction in Florida production would be increased fertilizer prices which would result from competition for restricted supplies of phosphate rock for domestic and export use.

Figure 15.—World production of phosphate rock, by relative share, 1977.

Table 42.—World production of phosphate rock, by country

(Thousand metric tons)

Country[1]	1973	1974	1975	1976	1977 [p]
North America:					
United States	38,226	41,446	44,285	44,662	47,256
Mexico	72	194	282	224	200
Netherlands Antilles	93	107	82	54	79
South America:					
Argentina (guano)	1	([2])	1	0	0
Brazil	286	[r]327	406	490	605
Chile (guano)	13	19	14	16	[e]16
Colombia	10	10	13	10	[e]10
Peru	23	([3])	([3])	2	0
Venezuela	30	142	116	80	139
Europe					
France	29	19	18	18	28
Germany, Federal Republic of	93	85	82	85	65
U.S.S.R.[4]	21,228	22,498	24,131	24,222	24,200
Africa:					
Algeria	612	[r]789	707	820	1,055
Egypt	533	507	536	433	581
Morocco	17,077	19,721	13,548	15,656	17,027
Senegal:					
Aluminum phosphate	219	406	201	208	1,869
Calciumphosphate	1,533	1,472	1,600	1,591	
Seychelles (guano)[5]	7	7	[e][r]6	6	6
South Africa, Republic of[6]	1,365	[r]1,419	1,647	1,702	2,403
Spanish Sahara	697	[r]2,300	2,760	172	232
Togo	2,292	2,572	1,160	2,009	2,857
Tunisia	3,473	[r]3,810	3,488	3,301	3,614
Uganda[e]	15	15	15	15	5
Zimbabwe-Rhodesia[e]	150	[r]127	[r]130	130	140
Asia:					
China, Mainland[e]	2,994	2,994	3,400	3,750	4,100
Christmas Island	1,538	1,764	1,392	1,032	1,186
India:					
Apatite	10	12	30	38	[e]750
Phosphate rock	135	[r]434	429	613	
Israel	780	1,026	882	639	1,232
Jordan	1,106	[r]692	1,112	1,702	1,781
Korea, North (apatite)[e]	363	399	454	454	500
Philippines:					
Guano	([2])	14	126	2	[e]2
Phosphate rock	12	26	5	12	[e]12
Syria	150	602	857	511	425
Vietnam[e]	499	1,179	1,400	1,500	1,500
Oceania:					
Australia	5	2	140	258	485
Nauru Island	2,323	2,288	1,533	755	1,146
Ocean Island	744	562	516	417	416
Total	[r]98,754	[r]109,987	107,278	106,955	116,000

[e] Estimated. [p] Preliminary. [r] Revised.
[1] In addition to the countries listed, Belgium, Indonesia, and Tanzania may have continued to produce phosphate rock, and the Territory of South-West Africa produced guano, but output was not officially reported, and available information is inadequate for the formulation of reliable estimates of output levels.
[2] Less than ½ unit.
[3] Revised to none.
[4] Estimated by the International Superphosphate Manufacturers' Association on the basis of a marketable product averaging 34.8 percent P_2O_5.
[5] Exports.
[6] Local sales and exports of phosphate concentrate and direct-sale ore.

Table 43.—Identified world phosphate reserves and resources

(Million metric tons)

Continent	Reserves[1]	Total identified resources
North America	2,200	8,100
South America	450	950
Europe	1,415	3,445
Africa	22,180	51,450
Asia	660	1,350
Oceania	100	2,130
Total[2]	27,000	67,000

[1] Estimated reserves at 1977 costs and prices.
[2] Data may not add to totals shown because of independent rounding.

World Trade

World trade in phosphate rock and phosphatic fertilizer is complex, with demand for phosphate rock and fertilizer interrelated. Morocco, the United States, the U.S.S.R., and the Pacific islands of Nauru, Banaba (Ocean Island), and Christmas are the principal exporters of phosphate rock. Western Europe, Eastern Europe, Japan, Canada, and South America are the major importers. Florida (including North Carolina) exported an estimated 40 percent of its phosphate as rock and fertilizer in 1977 and 1978, accounting for an estimated 95 percent of all U.S. exports of phosphate rock in those years. Exports of Florida phosphate rock are expected

Table 44.—Major phosphate rock exporters

(Thousand metric tons)

Exporter	1971	1972	1973	1974	1975	1976	1977[1]
Morocco:							
Marketable production	12,013	14,971	17,077	19,721	13,548	15,656	17,027
Exports	11,886	13,559	16,104	18,691	13,105	14,652	15,792
Tunisia:							
Marketable production	3,162	3,387	3,473	[r]3,810	3,488	3,301	3,614
Exports	2,410	2,306	2,226	2,407	1,725	1,857	1,898
Togo:							
Marketable production	1,715	1,928	2,292	2,572	1,160	2,009	2,857
Exports	1,762	1,855	2,292	2,633	1,174	2,001	2,886
U.S.S.R.:							
Marketable production	21,591	22,498	[2]21,228	[2]22,498	[2]24,131	[2]24,222	24,200
Exports[3]	2,145	NA	6,552	5,945	5,807	4,870	4,243
U.S. Total:							
Marketable production	35,277	37,041	38,226	41,437	44,276	44,662	47,256
Exports	11,419	12,464	12,587	12,605	11,131	9,433	13,230
Florida: Exports	10,767	11,895	11,863	12,116	10,270	9,013	12,937

[r] Revised. NA Not Available.
[1] Data from Phosphate Rock, Minerals Commodity Profile, Bureau of Mines, 1978.
[2] Estimated by the International Superphosphate Manufacturers' Association on the basis of a marketable product averaging 34.8 percent P_2O_5.
[3] To Western Europe only.

Table 45.—Exports of phosphate rock, by destination

(Thousand metric tons and thousand dollars)

Destination	1975 Quantity	1975 Value	1976 Quantity	1976 Value	1977 Quantity	1977 Value
Florida phosphate rock:						
Austria	25	144	97	4,173	151	4,310
Belgium-Luxembourg	643	29,641	750	26,610	899	22,797
Brazil	509	24,270	645	25,655	558	16,500
Canada	2,380	67,367	1,787	41,566	2,049	41,583
Chile	26	1,878	0	0	0	0
Colombia	44	2,200	16	573	53	1,626
Costa Rica	0	0	11	325	0	0
Ecuador	15	709	20	704	10	304
El Salvador	5	217	11	426	11	270
France	519	19,133	534	16,480	1,051	23,486
Germany Democratic Republic	0	0	16	401	0	0
Germany, Federal Republic of	534	20,136	506	14,085	978	21,895
India	226	9,655	237	11,218	249	8,556
Iran	376	23,614	277	9,349	366	12,279
Ireland	0	0	23	656	23	598
Italy	207	8,540	95	3,157	297	7,149
Japan	1,671	80,721	1,375	53,311	1,479	48,094
Korea, Republic of	608	30,538	692	30,059	1,165	36,344
Mexico	950	40,141	394	12,378	566	14,126
Netherlands	522	18,822	688	19,852	824	18,922
Norway	75	2,837	55	2,104	154	4,024
Peru	10	495	5	184	16	494
Philippines	131	7,232	76	2,950	100	3,322
Poland	423	19,662	190	6,328	935	21,151
Portugal	0	0	4	129	5	121
Romania	131	6,216	153	4,926	259	6,590
Spain	47	1,188	16	424	142	3,246
Sweden	63	2,987	103	3,876	120	3,349
Switzerland	0	0	24	871	0	0
Taiwan	15	863	45	1,727	32	1,208
United Kingdom	117	5,673	164	5,416	405	10,187
Other	1	45	2	139	(1)	1
Total[2] Florida exports	10,270	424,924	9,011	300,052	12,937	333,891
Other U.S. phosphate rock, total[3]	1,166	36,629	983	27,358	1,077	28,332
Grand total[2]	11,436	461,533	9,994	327,410	14,014	362,223

[r] Revised.
[1] Less than ½ unit.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes coloidal and sintered matrix from Tennessee, Idaho, and Montana and soft phosphate rock.

Table 46.—International phosphate rock and fertilizer shipments from Florida,[1] 1976

Destination	Phosphate rock			Phosphate fertilizer		
	Quantity, net metric tons	Percent of total net tonnage	Value	Quantity, net metric tons	Percent of total net tonnage	Value
Algeria	23,972	0.28	$1,723,751	23,829	0.89	$1,348,338
Argentina	0	NAp	0	30,616	1.14	3,846,026
Australia	0	NAp	0	15,999	.59	2,021,608
Bangladesh	0	NAp	0	31,828	1.18	3,889,210
Belgium-Luxembourg	761,603	8.89	26,917,720	126,393	4.70	12,480,527
Belize	0	NAp	0	1,637	.06	283,647
Benin	0	NAp	0	473	.02	57,960
Bermuda	0	NAp	0	78	NAp	12,597
Brazil	712,414	8.13	28,349,462	660,049	24.56	63,480,278
Canada	1,091,296	12.73	22,797,757	90,614	3.37	10,064,881
Canary Islands	0	NAp	0	2,000	.07	204,000
Chile	0	NAp	0	86,610	3.22	7,800,840
Colombia	16,733	.20	572,558	31,934	1.19	3,834,648
Costa Rica	12,053	.14	518,012	21,453	.80	2,593,813
Denmark	0	NAp	0	22,364	.83	1,883,086
Dominican Republic	0	NAp	0	17,861	.66	2,063,857
Ecuador	19,541	.23	703,633	0	NAp	0
El Salvador	10,671	.12	425,780	22,417	.83	2,712,992
England	145,105	1.69	4,464,650	2,751	.10	365,883
Ethiopia	0	NAp	0	7,376	.27	412,354
France	580,719	6.78	17,500,107	267,049	9.94	31,198,908
Germany, Federal Republic of	331,147	3.86	9,986,601	92,502	3.44	9,493,903
Guyana	1,225	.01	60,000	941	.04	121,156
India	237,119	2.78	11,217,893	0	NAp	0
Iran	280,195	3.27	9,349,383	0	NAp	0
Ireland	28,036	.33	1,259,883	24,688	.92	1,906,913
Italy	71,884	.84	2,502,053	263,647	9.81	31,095,300
Ivory Coast	0	NAp	0	7,866	2.9	989,552
Jamaica	0	NAp	0	2,880	.11	321,224
Japan	1,372,759	16.02	53,203,460	173,858	6.47	32,072,533
Korea, Republic of	692,460	8.08	30,059,481	0	NAp	0
Malaysia	0	NAp	0	6,202	.23	775,246
Martinique	0	NAp	0	200	.01	39,600
Mauritius	0	NAp	0	2,987	.11	358,443
Mexico	375,058	4.38	12,374,600	0	NAp	0
Netherlands	1,046,482	12.21	31,140,738	5,000	.19	409,996
New Zealand	1,000	.01	109,995	1,499	.06	164,900
Nicaragua	0	NAp	0	1,426	.05	220,326
Norway	55,278	.64	2,104,020	0	NAp	0
Pakistan	0	NAp	0	249,323	9.35	32,803,936
Panama	31,839	.37	1,163,731	0	NAp	0
Peru	5,490	.06	184,193	0	NAp	0
Philippines	76,523	.89	2,949,990	0	NAp	0
Poland	218,831	2.55	7,132,405	48,956	1.82	5,338,142
Portugal	3,842	.04	129,466	7,199	.27	879,297
Romania	178,841	2.09	5,606,751	0	NAp	0
Sicily	23,775	.28	654,199	0	NAp	0
Singapore	0	NAp	0	2,500	.09	378,520
South Africa, Republic of	0	NAp	0	3,729	.13	1,134,026
Spain	16,249	.19	423,751	10,017	.37	1,202,062
Sweden	102,355	1.19	3,875,921	0	NAp	0
Taiwan	46,758	.55	1,913,920	15,347	.57	1,676,534
Thailand	0	NAp	0	1,500	.06	127,469
Trieste	0	NAp	0	97,324	3.62	9,828,363
Trinidad	0	NAp	0	766	.03	107,586
Turkey	0	NAp	0	25,103	.93	2,384,767
Uraguay	0	NAp	0	41,636	1.55	4,655,485
Wales	0	NAp	0	4,202	.16	1,790,487
Yugoslavia	0	NAp	0	131,359	4.89	12,786,017
Total	8,571,053	NAp	291,386,656	2,687,365	NAp	303,616,506

NAp Not applicable.

[1] Includes shipments from the Florida Ports of Tampa, Jacksonville, and Boca Grande, as well as the Port of Morehead City, N.C., which accounted for about 3 pct of the total shipments.

Source: Port of Tampa Authority.

to increase through 1985. Due to increases in international transportation costs, it is anticipated that there will be a trend toward the export of higher value phosphate fertilizer products.

Total world trade in phosphate rock was approximately 38 million metric tons in 1977. Florida and Morocco had combined exports of more than 23 million metric tons, or more than 77 percent of the total exports by major phosphate rock producers (table 44). Morocco, from which transportation costs to European markets are lower than from Florida, accounted for a large share of the more than 29 million metric tons of phosphate rock that was imported into Europe in 1977. Florida sales to Europe have nonetheless been stable in the recent

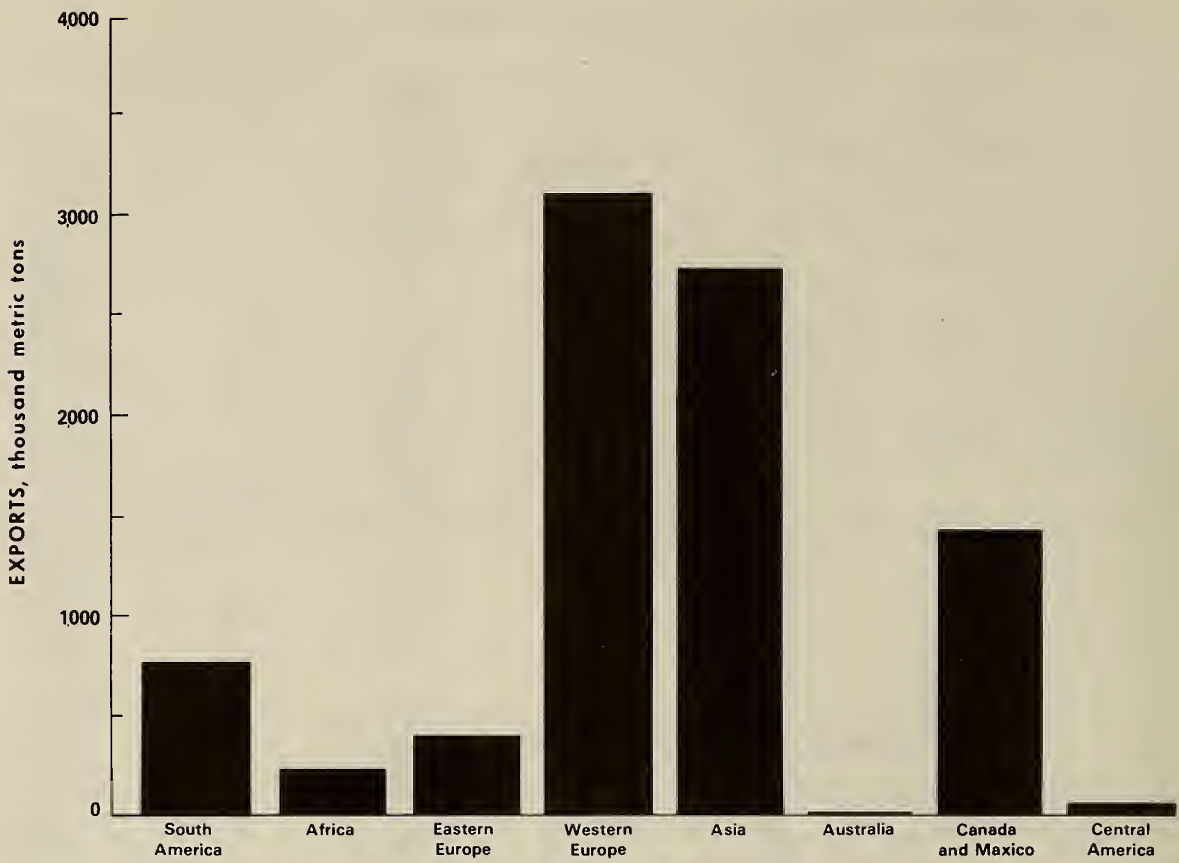


Figure 16.—Florida exports of phosphate rock, by destination, 1976.

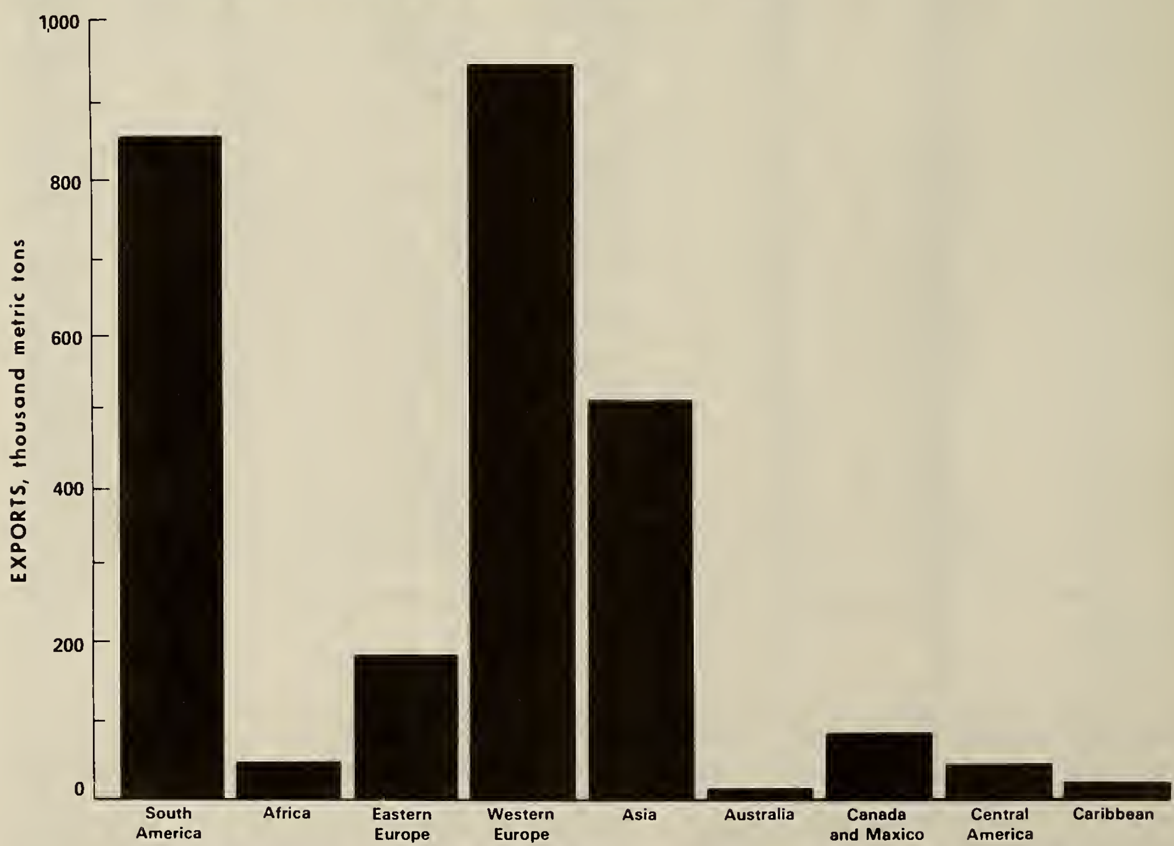


Figure 17.—Florida exports of phosphate fertilizer, by destination, 1976.

past, and Western Europe is expected to continue to be a viable market for Florida phosphate rock because of the reliability of the source and the demand for a diversified source of supply.

The Soviet phosphate mining industry, with estimated production stabilized at 24 million metric tons for the third successive year in 1977 (table 44), maintained its position as the world's second largest producer. In that same year the U.S.S.R. exported more than 4 million metric tons of phosphate rock.

Several of the developing nations are expanding their phosphate industries. North Africa, which includes Morocco, Algeria, Tunisia, and the Sahara Desert, has phosphate rock reserves estimated at more than 19.5 billion metric tons. In 1978 the countries of North Africa produced some 24.5 million metric tons of phosphate rock, reflecting a 12-percent increase over 1977 production. This fell short, however, of the record high for the region, set in 1974, when North Africa produced 26.8 million metric tons of phosphate rock.

Despite strong foreign competition, Florida phosphate rock production has maintained a position of importance throughout the world (table 45). Exports of Florida rock (including those of North Carolina) rose from almost 9 million metric tons in 1976 to more than 13 million metric tons in 1977. Approximately 35 percent of the 1977 exports went to Western Europe, and another 24 percent went to Asia, principally to Japan and the Republic of Korea. The balance was exported to Canada, Poland, and Latin America. Florida's exports of phosphate rock and fertilizers for 1976 are shown in table 46 and in figures 16 and 17.

World phosphate rock prices reached a peak in 1974. The next four years saw a gradual decline of prices, but by the latter part of 1978 prices started to turn up again. It is anticipated that phosphate rock prices will increase into the 1980's.

CONCLUSIONS

The central Florida phosphate district is the largest phosphate producing region in the world. In 1978 it accounted for more than one-third of world production. Based on the data and analyses presented in this report, the following conclusions concerning the Florida phosphate industry were drawn:

1. It was projected that in 1981 the phosphate industry will contribute the following benefits to the Florida economy: approximately 48,500 jobs and nearly $1.4 billion[13] in gross output, including $448 million in personal income. These economic benefits are generally localized where the phosphate rock mining and fertilizer manufacturing industry, the transportation industry, and other related industries are located; that is, in Polk, Hillsborough, Hamilton, and Columbia Counties.

2. The Florida phosphate industry has a substantial impact on the national economy. It was projected that 60,000 jobs and more than $1.4 billion in gross output, including $391.0 million in personal income, will be generated outside Florida by the Florida phosphate industry in 1981. It was further projected that nationwide the Florida phosphate industry will account for approximately 100,000 jobs and $2.8 billion of gross output, including $839 million in personal income, in 1981.

3. It was estimated that total nationwide tax payments generated by the phosphate industry will exceed $316 million in 1981, with more than $99 million of that total expected to be paid to Florida governments.

4. The net positive contribution of the Florida phosphate industry to the U.S. balance of payments in 1981 was estimated at approximately $961.8 million.

5. If it were not for the Florida phosphate industry, the United States would have to import a major share of its phosphate requirements. The result would probably be higher food prices, assuming that imported phosphate would be costlier than domestic phosphate and assuming no offsetting increase in agricultural productivity. Higher food prices would in turn result in a corresponding decline in real income and living standards.

6. The Florida phosphate fertilizer industry consumes about 50 percent of all U.S. sulfur production. It was estimated that in 1981 the Florida fertilizer industry will represent a $480 million market for sulfur.

7. The fluorine contained in phosphate rock is adequate to supply a major share of U.S. demand, thereby reducing fluorine imports proportionately. Over the productive life of Florida's phosphate land-pebble deposits, it was estimated that $140 million worth of fluorine can be recovered.

8. Uranium with an estimated value of $3.23 billion could potentially be recovered from the processing of Florida phosphate rock in 1981, assuming a uranium oxide (U_3O_8) price of $42 per pound. This estimate was based on byproduct recovery of U_3O_8 from phosphoric acid production. Uranium produced as a primary product from Florida phosphate rock would not be economically competitive with other uranium ores.

9. Two phosphate industry impact regions were defined in Florida, the central Florida region of Polk and Hillsborough Counties and the northern Florida region of Hamilton and Columbia Counties. Total 1977 wages and salaries of over $419 million were attributable to the industry in central Florida. In the northern Florida region, approximately $40.7 million was linked to the industry. An estimated 13 percent of the central Florida region's wages and salaries and 40 percent of the northern Florida region's wages and salaries were related to the phosphate industry. Approximately 8 percent of the central Florida region's employment was linked to the phosphate industry, and 21 percent of the employment in the northern Florida region was linked to the phosphate industry.

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[13]All monetary estimates in this section are in 1977 dollars.

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APPENDIX A.—METHODOLOGY OF IMPACT ANALYSIS

Input-output (I-O) analysis is concerned with the interdependence among economic sectors. In this study, two I-O models were developed for economic impact analysis with respect to the Florida phosphate industry. The two models were based upon the economy of Florida and the national economy of the United States.

The Florida phosphate industry includes the Standard Industrial Classifications (SIC's) 1475, phosphate rock mining and beneficiation; 2874, phosphatic fertilizer manufacturing; and 2819, industrial inorganic chemicals (not elsewhere classified). These SIC's were used in constructing the two previously mentioned I-O models, and it was from these SIC's that the economic impact multipliers used in this study were derived. In the sources of available data, all three SIC sectors are treated as individual industries. Because of disaggregation problems, it was assumed for purposes of this study that SIC 287, agricultural chemicals, is representative of SIC 2874 for multiplier derivation purposes.

The following is a description of impact multipliers taken from "The Input-Output Structure of the U.S. Mineral Industries: Transactions, Employment, and Multipliers," a report written by H. C. Davis and E. M. Lofting (*8*) under contract to the Bureau of Mines:

Economic Multiplier Analysis

The theory and application of multiplier analysis has been dealt with comprehensively by Miernyk (1),[1] Richardson (2), and Moore and Petersen (3). Brief coverage of the concepts is presented here to provide an orientation.

In general, the analyst seeks to determine the repercussions in terms of employment and income of various expenditures made in the economy. Prior to the development of input-output tables attempts were made to estimate multiplier effects in an aggregate manner for the entire economy. The earliest efforts are usually traced to Kahn (4) and Keynes (5).

With the advent of input-output techniques, multiplier analysis could be carried out for individual sectors of an economy in a more refined fashion. Since the Leontief inverse of the table of interindustry flows provides the direct and indirect (total) requirements by sector, per unit of output of final demand, the inverse can readily be used to determine the overall impacts that changes in expenditure levels can cause.

Multipliers can be calculated in different ways to serve different purposes. The most commonly encountered multipliers are (i) output multipliers, (ii) employment multipliers, and (iii) income multipliers. Employment and income multipliers can be calculated so as to show direct plus indirect effects (Type I) or direct plus indirect plus *induced* effects (Type II). The Type I and Type II multipliers are treated in subsection (iv).

(i) Output Multipliers

Output (or column) multipliers measure the total direct and indirect requirements needed from all sectors to deliver one unit of output from a given sector to final use. These multipliers are calculated by summing the entries in the columns of the Leontief inverse, hence the alternate designation "column" multipliers. The output multipliers measure the total requirements per unit of final demand, and thus indicate the degree of structural dependence of each sector on all other sectors of the economy. A critically important concept regarding this type of multiplier should be stressed.

As normally calculated, the output multiplier represents total requirements per *unit change in final demand*. In many analyses the problems as posed involve the calculation not of changes in final demand but of direct changes in output, i.e., plant closings, port shutdowns, resource constraints, (e.g. such as droughts or other disasters) which directly impact on the industrial output of certain regional sectors without fundamentally altering the level of final demand. In fact, final demand may be satisfied by alternative supply sources. In these instances the appropriate impact multipliers are related to *the unit change in output* and are calculated by dividing each element in the columns of the Leontief inverse by the on-diagonal entry of the particular column. (6) The resulting matrix will have elements somewhat smaller than those of the original Leontief inverse and these multipliers (the column sums of this matrix) will consequently also be smaller than those derived on the basis of output to final use.

(ii) Employment Multipliers

In many instances changes in expenditure patterns will increase or decrease levels of employment. Input-output analysis provides the means to quantify these changes on a sector by sector basis.

The Bureau of Labor Statistics typically develops labor, or employment interactions matrices, based on the BEA national input-output tables.

> "In order to make the . . . input-output table more useful for manpower analysis, the Division of Economic Growth has converted the inverse form of the table into manpower requirements. The original table, which shows the direct and indirect industry output generated by a dollar's worth of final demand, has been used, along with estimates of . . . levels of labor productivity . . . to provide estimates of the direct and indirect employment requirements per billion dollars of final demand . . . The basic input-output relationships were left unchanged" (7).

The calculations of "estimates of labor productivity" are based on the employment-production function approach using linear regression methods. This technique was elaborated by Moore and Petersen (8). The functions take the form of

$$E_i^t = m_i x_i + c_i$$

where E is employment in man-years, x is output in constant dollars over the time span of available data, and c is the intercept value.

The employment multipliers can be calculated by multiplying each row element (b_{ij}) in the Leontief inverse by the appropriate (m_i) to form a manpower requirements matrix. The columns of this matrix are then summed as in the development of output multipliers described above. The employment multiplier (E^m) is formed by dividing this column sum for each sector (i) by the initial (m_i).

(iii) Income Multipliers

The simple income multiplier expresses the ratio of the direct plus indirect income change in a given sector to the initial direct change:

$$M_i = \frac{\Sigma a_{h_j} b_{ji}}{a_{h_i}}$$

Where M_i is the income multiplier, b_{ji} is an element of the Leontief inverse, and a_{h_j} is the element of the household row.

[1]These references are listed at the end of this quoted material.

(iv) Type I and Type II—Employment and Income Multipliers

The employment and income multipliers described above in sections (ii) and (iii) are designed to measure the direct and indirect effects that result from a change in some given level of spending. As the income from the initial stimulus is respent on other goods and services, there are further changes in income. These second, and succeeding, round effects are referred to as "induced" effects. Multipliers which are designed to estimate the direct plus indirect effects are termed Type I or "simple" multipliers. Those which are formed to estimate direct plus indirect plus induced effects are called Type II multipliers. Type II multipliers can be estimated either by applying appropriate sectoral consumption functions to the economy under study and calculating the accretions to income from the second and succeeding rounds of expenditures, or, by partially "closing" the input-output model. This closing is achieved by augmenting the processing sectors with the household row and household column and forming a new Leontief inverse. The elements of the new inverse are slightly larger and provide the basis for calculating the Type II multipliers.

In the case of Type I and Type II income multipliers, it has been noticed that for a given economy the two multipliers will always differ by a constant factor which is the same for all sectors. This factor appears to range generally between one and three.

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[2]This reference list applies only to the preceding quoted material.

Using the above methodology, two sets of multipliers were calculated. The first set, which is shown in table A-1, included the national impact multipliers derived from a 404-sector I-O table which included an expanded 44-sector mining industry. Table A-1 can be read as follows: The employment multiplier per million dollars of output of phosphate rock is equal to the direct employment (16.39216), in workers per million dollars of output, plus the net indirect employment (45.89812 − 16.39216), plus the net induced employment (132.58181 − 45.89812).

The type I multiplier equals the ratio of the indirect employment to the direct employment, and the type II multiplier equals the ratio of the induced employment to the direct employment. The output multiplier is the sum of the column of the phosphate rock mining industry in the Leontief inverse, or the $(I-A)^{-1}$, where I is the identity matrix and A is the direct-input coefficients matrix derived from the total requirements table.

The personal income multipliers in both tables and the employment multipliers in table A-2 have solutions that are analogous to the solution used to compute the employment multipliers for table A-1.

Table A–1.—Impact multipliers derived from a 404-sector national input-output (I-O) table for 1972

(Per million dollars of output)

Phosphate subindustry	Direct	Indirect	Induced	Multiplier		
				Type I	Type II	Output
Employment:						
Phosphate rock	16.39216	45.89812	132.58181	2.80000	8.08812	1.9616
Industrial chemicals	11.15755	34.55027	104.25907	3.09658	9.34426	1.9506
Fertilizers	14.78383	50.30041	139.29741	3.40239	9.42228	2.3753
Personal income:						
Phosphate rock	.28913	.55016	1.24334	1.90280	4.30023	1.9616
Industrial chemicals	.22821	.45868	1.01173	2.00985	4.43326	1.9506
Fertilizers	.21212	.56765	1.27881	2.67615	6.02883	2.3753

Table A–2.—Impact multipliers derived from a 338-sector Florida I-O table for 1972

(Per million dollars of output)

Phosphate subindustry	Direct	Indirect	Induced	Multiplier		
				Type I	Type II	Output
Employment:						
Phosphate rock	18.72889	35.28923	78.82812	1.88421	4.20891	1.5440
Industrial chemicals	11.79977	21.35656	49.39388	1.80991	4.18600	1.3338
Fertilizers	19.72519	34.33481	66.42918	1.74066	3.36773	1.5738
Personal income:						
Phosphate rock	.34728	.53532	.87726	1.54144	2.52606	1.5440
Industrial chemicals	.24005	.34559	.56553	1.43963	2.35585	1.3338
Fertilizers	.22312	.39505	.64704	1.77057	2.89998	1.5738

APPENDIX B.—DIRECT IMPACT OF THE FLORIDA PHOSPHATE COMPLEX ON FLORIDA AND THE UNITED STATES

The direct impact of the Florida phosphate complex on the U.S. economy can be measured by the input coefficients, or input requirements, given in tables B–1, B–2, and B–3. The input coefficients were obtained by dividing the 1976 dollar value of specific industry purchases by the 1976 dollar value of production. This was done for all purchases at the two-digit Standard Industrial Classification (SIC) level for each of the three sectors of the phosphate complex. Thus the input coefficients show the distribution of inputs for each dollar of production. For example, in the mining sector about $0.0004 cents out of every dollar of output represented purchases of lumber and wood products. All of the purchased inputs shown in table B–1 amount to approximately $0.58. The residual amount of about $0.42 includes profits and other items not specified in the table.

The National Impact

MINING SECTOR PURCHASES

The Florida and North Carolina mining sector produced approximately 37,697,000 metric tons of bulk phosphate valued at $867,090,000 in 1976, according to a Bureau of Mines estimate. These figures represent a unit price of $23 per metric ton of marketable production. Almost all of this production occurred in central Florida.

The pricing of marketable phosphate rock production varies greatly, depending on the end use of the phosphate. Over 20 percent of Florida's production is exported from the Ports of Tampa, Boca Grande, and Jacksonville. The price per metric ton of high-grade (75 bone phosphate of lime) phosphate rock exported from the Port of Tampa in 1976 was $34. In contrast, the average cost of production of a metric ton of phosphate rock (wet) at the mine was estimated for Florida severance tax purposes to be $10.85. Because of the great variation in the unit price of marketable phosphate as reported by the industry, all Florida production was valued at the 1976 national average unit price of $21.25 per metric ton (f.o.b. plant) for the purpose of computing the input coefficients shown in tables B–1, B–2, and B–3. This price is higher, on the average, than the transfer price established by most Florida mining operations for internal transfers. Most of Florida's marketable phosphate rock is used in Florida in intergrated chemical production facilities. Most phosphate produced and used in the State is not sold through organized markets.

Table B–1 underscores the effect of using a national average price to value Florida's phosphate production. The higher price results in a residual of over $0.42 per dollar of output. Nonetheless, the relative importance of purchased inputs can be effectively shown using data based on the national average unit price rather than the transfer price reported by the industry.

The most important mining sector input in 1976 was contract work and services, as shown in table B–1. This input amounted to about $0.14 out of every dollar of mining production. A comparison of this and other inputs shown in tables B–1, B–2, and B–3 suggests that production requirements for the mining sector are quite different from those of other sectors in the complex.

Labor costs, including fringe benefits, were the next most important expenditure item in the mining sector, amounting to about 10 percent of the value of production. The relatively low labor cost in the phosphate mining sector reflects the high level of capital intensity in this sector.

Electric utility services were also important purchased in-

Table B–1.—Estimated input requirements as a percentage of total production for the phosphate mining sector of the Florida phosphate complex, 1976[1]

	SIC[2]	Input requirement[3]	Inputs originating in Florida, estimated percentage
Lumber and wood products	24	0.0004	100
Chemicals and allied products	28	.0401	46
Petroleum refining and related industries	29	.0010	[4]0
Rubber and miscellaneous plastic products	30	.0006	80
Primary metal industries	33	.0114	63
Fabricated metal products	34	.0098	91
Machinery, except electrical	35	.0443	45
Electrical and electronic machines	36	.0156	80
Transportation equipment	37	.0019	68
Other supplies and parts	NAp	.0431	69
Electric services	4911	.0879	100
Natural gas distribution	4924	.0051	100
Contract work and services	NAp	.1441	89
Labor	NAp	.0977	100
Sales tax	NAp	.0191	100
Property tax	NAp	.0281	100
Severance tax	NAp	.0290	100
Residual	NAp	.4208	NAp
Total	----------------	1.0000	NAp

NAp Not applicable.
[1] Based on data gathered through a Bureau of Mines survey and interviews by Florida State University personnel.
[2] Standard Industrial Classification.
[3] Input requirements were computed by dividing the 1976 dollar value of input purchases by the 1976 dollar value of production.
[4] Adjusted to reflect known industrial structure in Florida.

Table B–2.—Estimated input requirements as a percentage of total production for the phosphatic fertilizers sector of the Florida phosphate complex, 1976[1]

	SIC[2]	Input requirement[3]	Inputs originating in Florida, estimated percentage
Phosphate rock	1475	[4]0.1765	100
Sulfur	1477	.2119	[5]0
Paper and allied products	26	.0003	95
Chemicals and allied products	28	.0935	52
Petroleum refining and related industries	29	.0171	0
Rubber and miscellaneous plastic products	30	.0021	96
Stone, clay, glass, and concrete products	32	.0006	70
Primary metal industries	33	.0034	75
Fabricated metal products	34	.0096	91
Machinery, except electrical	35	.0171	66
Electrical and electronic machinery	36	.0049	86
Transportation equipment	37	.0005	100
Other supplies and parts	NAp	.0595	13
Electric services	4911	.0427	100
Natural gas distribution	4924	.0044	100
Contract work and services	NAp	.0284	93
Labor	NAp	.1080	100
Sales tax	NAp	.0272	100
Property tax	NAp	.0137	100
Residual	NAp	.1786	NAp
Total	----------------	1.0000	NAp

NAp Not applicable.
[1] Based on data gathered through a Bureau of Mines survey and interviews by Florida State University personnel.
[2] Standard Industrial Classification.
[3] Input requirements were computed by dividing the 1976 dollar value of input purchases by the 1976 dollar value of production.
[4] This represents a unit price for phosphate rock that is below the market price.
[5] Adjusted to reflect known industrial structure in Florida.

Table B–3.—Estimated input requirements as a percentage of total production for the industrial chemicals sector of the Florida phosphate complex, 1976[1]

	SIC[2]	Input requirement[3]	Inputs originating in Florida, estimated percentage
Phosphate rock	1475	0.1801	100
Silica	1446	.0066	0
Lumber and wood products, except furniture	24	.0007	100
Paper and allied products	26	.0002	100
Chemicals and allied products	28	.0012	0
Petroleum refining and related industries	29	.0170	[4]0
Rubber and miscellaneous plastic products	30	.0022	5
Primary metal industries	33	.1462	0
Fabricated metal products	34	.0030	0
Machinery, except electrical	35	.0095	3
Electrical and electronic machinery	36	.0264	100
Transportation equipment	37	.0005	0
Other supplies	NAp	.0877	NAp
Electric services	4911	.2111	100
Natural gas distribution	4924	.0133	100
Contract work and services	NAp	.0092	100
Labor	NAp	.1191	100
Sales tax	NAp	.0050	100
Residual	NAp	.1610	NAp
Total	----------------	1.0000	NAp

NAp Not applicable.
[1] Based on data gathered through a Bureau of Mines survey and interviews by Florida State University personnel.
[2] Standard Industrial Classification.
[3] Input requirements were computed by dividing the 1976 dollar value of input purchases by the 1976 dollar value of production.
[4] Adjusted to reflect known industrial structure in Florida.

Table B–4.—Production by the Florida fertilizer chemicals sector and estimated value, 1976

Subsector	Quantity, thousand metric tons	Value, thousands	Unit price
Sulfuric acid	[1]223	$7,405	[2]$33.18
Phosphoric acid	[1]1,382	286,004	[3]207.00
Superphosphates and other phosphatic fertilizer materials including diammonium phosphate	2,990	310,285	[3]103.77
Total	-------------	603,694	NAp

NAp Not applicable.
[1] Figure is for interfirm shipments, rather than actual production, since product is primarily used internally.
[2] Based on Florida shipments.
[3] Based on national shipments.
Source: U.S. Department of Commerce, Bureau of the Census, and personal interviews.

puts in this sector. Electricity accounted for about $0.09 out of every dollar of output. Despite the large volumes of electricity purchased, there were no self-generators of electricity in the sector; all electricity was purchased from public utilities.

Other significant inputs in the mining sector were chemical and allied products, machinery, and inputs from the primary metals industries. The sector also paid significant State and local taxes. Severance, sales, and property taxes amounted to approximately $0.075 per dollar of mining sector output in 1976. This does not include the payment of a small State corporate income tax.

PHOSPHATIC FERTILIZERS SECTOR PURCHASES

The phosphate fertilizers sector is the most important processing sector of the Florida phosphate complex. The major fertilizer chemicals produced by this sector are sulfuric acid, phosphoric acid, diammonium phosphate, superphosphates, and other phosphatic fertilizer materials. The value of total interplant marketed production by Florida facilities in 1976 was estimated to be $603,700,000 (table B–4).

The Florida phosphatic fertilizers sector is a major producer of sulfuric and phosphoric acid. However, a large portion of this production is used internally in the production of phosphatic fertilizers. The estimate of $603,700,000 represents marketable production not used in further processing in the phosphatic fertilizers sector and therefore understates the actual physical output of some of the products of this sector.

The superphosphates, diammonium phosphates, and other phosphatic fertilizer materials represent final products of the sector. Production of these products results in either interfirm shipments or inventory accumulation. It should be emphasized that the figures given in table B–4 for sulfuric and phosphoric acid represent only interfirm movements of these products. Sulfuric acid and phosphoric acid used on an interfirm basis are intermediate products, and the value of these intermediate products is represented in the price of the final products (superphosphates, diammonium phosphates, and other fertilizer materials).

The importance of various purchased inputs relative to the marketed production of the phosphatic fertilizers sector is apparent from table B–2. Raw material inputs in the form of phosphate rock, ammonia, and sulfur accounted for about $0.48 out of every dollar of fertilizer chemical output in 1976. This figure, however, understates the actual value of raw materials purchased by the sector because the transfer price of phosphate rock is less than its market price. For purposes

Table B–5.—Estimated value of purchases (total and Florida only) by the phosphate mining sector of the Florida phosphate complex, 1976[1] [2]

	SIC[3]	Value of all purchases,[4] thousands	Value of Florida purchases, thousands
Lumber and wood products	24	$304.6	$304.6
Chemicals and allied products	28	30,538.5	14,047.7
Petroleum refining and related industries	29	761.6	0
Rubber and miscellaneous plastic products	30	456.9	365.5
Primary metal products	33	8,681.8	5,469.5
Fabricated metal products	34	7,463.3	6,719.6
Machinery, except electrical	35	33,737.1	15,181.7
Electrical and electronic machinery	36	11,880.3	9,504.2
Transportation equipment	37	1,447.0	984.0
Other Supplies and parts	NAp	32,823.2	22,648.0
Electrical service	4911	66,941.1	66,941.1
Natural gas distribution	4924	3,884.0	3,884.0
Contract work and services	NAp	109,740.8	97,669.3
Labor	NAp	74,404.4	74,404.4
Sales tax	NAp	14,545.8	14,545.8
Property tax	NAp	21,399.8	21,399.8
Severence tax	NAp	22,085.2	22.085.2
Total	--------------	441,095.6	376,226.4

NAp Not applicable.
[1] Based on data gathered through a Bureau of Mines survey and interviews by Florida State University personnel.
[2] The estimates presented are based on an output value of $761,560,000 for the Florida mining sector. This value represents 35.8 million metric tons of phosphate rock production valued at $21.25 per metric ton.
[3] Standard Industrial Classification.
[4] The total value of purchases from each industry (or labor purchased, or tax paid, where applicable) was obtained by multiplying the applicable input requirements per unit of output by the estimated value of mining output for Florida ($761,560,000).

of internal accounting, fertilizer chemical establishments underprice phosphate rock when estimating the cost of raw materials in their product in process.

Labor costs, including fringe benefits, amounted to about $0.11 out of each dollar of output. As was the case with the mining sector, this indicates a very capital-intensive production process.

Other important inputs in the phosphatic fertilizers sector include chemicals and allied products, electric services, and contract work and services. The sales tax collections and property tax payments of this sector amounted to over $0.04 for every dollar of output.

INDUSTRIAL CHEMICALS SECTOR PURCHASES

The industrial chemicals sector of the Florida phosphate complex is relatively insignificant compared to the mining and fertilizer sectors. The basic output of this sector is elemental phosphorus, which is used in a wide variety of industrial activities.

The primary input requirements in the industrial chemicals sector are phosphate rock, coke, electric services, and labor, as shown in table B–3. The most important input, electric services, accounted for about $0.21 out of every dollar of production, making this sector the most energy-intensive sector of the complex. However, none of the Florida firms making up the industrial chemicals sector were self-generators of electricity. The industrial chemical sector, like the other two sectors, uses capital-intensive production processes.

Impact on Florida

MINING SECTOR PURCHASES

A very large percentage of phosphate mining sector purchases, as shown in tables B–1 and B–5, are obtained from Florida producers. Only one major input, petroleum products, is purchased exclusively outside the State. This does not mean that the mining sector does not purchase petroleum products from Florida jobbers and wholesalers, but rather that the petroleum products it purchases are not manufactured in the State. With this one exception, the impact of the phosphate mining sector is very significant for the economy of Florida. More than 85 percent of the value of the mining sector's 1976 purchases, as estimated in table B–5, were purchased from manufacturers in Florida. Including taxes and labor, these purchases amounted to about $376,226,000.

The significant mining sector inputs representing products bought from Florida firms are contract work and services and electrical services. These inputs were estimated at approximately $97,669,000 and $66,941,000, respectively, in 1976. In addition, wage payments by the mining industry have a significant impact on the central Florida region.

PHOSPHATIC FERTILIZERS SECTOR PURCHASES

The phosphatic fertilizers sector of the Florida phosphate complex has a relatively smaller impact on the Florida economy than does the mining sector. This is because the fertilizer sector obtains all of its sulfur and anhydrous ammonia, which are major purchased inputs for this sector, from sources outside the State. Sulfur, obtained primarily from the Gulf Coast area and Mexico, is used to produce sulfuric acid, which is consumed internally in the production of fertilizer chemicals. Anhydrous ammonia is used to make most of the solid forms of nitrogenous fertilizers.

Approximately 60 percent of all the sector's purchases were made in Florida in 1976, based on the data given in table B–6. The estimated value of these purchases was about $292,957,000. The most significant purchase was phosphate

Table B–6.—Estimated value of purchases (total and Florida only) by the fertilizer chemcials sector of the Florida phosphate complex, 1976[1] [2]

	SIC[3]	Value of all purchases,[4] thousands	Value of Florida purchases, thousands
Phosphate rock	1475	$106,552.0	$106,552.0
Sulfur	1477	127,922.8	0
Paper and allied products	26	181.1	172.0
Chemicals and allied products[5]	28	56,445.4	29,351.6
Petroleum refining and related industries	29	10,323.2	0
Rubber and miscellaneous plastic products	30	1,267.8	1,217.1
Stone, clay, glass, and concrete products	32	362.2	253.5
Primary metal industries	33	2,052.6	1,539.4
Fabricated metal products	34	5,795.5	5,273.9
Machinery, except electrical	35	10,323.2	6,813.3
Electrical and electronic machinery	36	2,958.1	2,544.0
Transportation equipment	37	301.8	301.8
Other supplies and parts	NAp	35,919.8	4,669.6
Electric services	4911	25,777.7	25,777.7
Natural gas distribution	4924	2,656.3	2.656.3
Contract work and services	NAp	17,144.9	15,944.8
Labor	NAp	65,199.0	65,199.0
Sales tax	NAp	16,420.5	16,420.5
Property tax	NAp	8,270.6	8,270.6
Total	----------------	495,874.5	292,957.1

NAp Not applicable.

[1] Based on data gathered through a Bureau of Mines survey and interviews by Florida State University personnel.

[2] The estimates presented are based on an output value of $603,694,000 for the Florida fertilizer chemicals sector. This output value was estimated from U.S. Department of Commerce, Bureau of the Census, data.

[3] Standard Industrial Classification.

[4] The total value of purchases from each industry (or labor purchased, or tax paid, where applicable) was obtained by multiplying the applicable input requirement per unit of output by the estimated value of fertilizer chemicals output for Florida ($603,694,000).

[5] A major item in this category is ammonia.

Table B–7.—Estimated value of purchases (total and Florida only) by the industrial chemicals sector of the Florida phosphate complex, 1976 [1] [2]

	SIC[3]	Value of all purchases,[4] thousands	Value of Florida purchases, thousands
Phosphate rock	1475	$4,654.6	$4,654.6
Silica	1466	170.6	0
Lumber and wood products, except furniture	24	18.1	18.1
Paper and allied products	26	5.2	5.2
Chemicals and allied products	28	31.0	0
Petroleum refining and related Industries	29	439.4	0
Rubber and Miscellaneous plastic products	30	56.9	2.8
Primary metal industries	33	3,778.5	0
Fabricated metal products	34	77.5	0
Machinery, except electrical	35	245.5	7.4
Electrical and electronic machinery	36	682.3	682.3
Transportation equipment	37	12.9	0
Other supplies	NAp	2,266.6	NA
Electrical supplies	4911	5,455.8	5,455.8
Natural gas distribution	4924	343.8	343.8
Contract work and services	NAp	237.8	237.8
Labor	NAp	3,078.1	3,078.1
Sales tax	NAp	129.2	129.2
Residual	NAp	2,620.7	0
Total	---------------	24,304.5	14,615.1

NA Not available. NAp Not applicable.

[1] Based on data gathered through a Bureau of Mines survey and interviews by Florida State University personnel.

[2] The estimates presented are based on an output value of $25,844,450 for the Florida industrial chemicals sector. This value was estimated from wage and salary data for the sector.

[3] Standard Industrial Classification.

[4] The total value of purchases for each industry (or labor purchased, or tax paid, where applicable) was obtained by multiplying the applicable input requirement per unit of output by the estimated value of industrial chemicals output for Florida ($603,694,000).

rock, which was valued at $106,552,000. Altogether, $29,352,000 worth of chemical products were purchased from Florida manufacturers as inputs to the phosphatic fertilizers sector. This was over half the value of all chemicals purchased as inputs by the sector. The sector purchased about $25,777,000 worth of electricity in Florida in 1976, reflecting its extensive use of electrical machinery.

Wage and salary payments to Florida residents were estimated at approximately $65,199,000.

INDUSTRIAL CHEMICALS SECTOR PURCHASES

The industrial chemicals sector has the smallest impact on the State of any of the three sectors studied. The value of total Florida output from this sector was estimated at $25,844,450 for 1976, with elemental phosphorus accounting for most of the sector's production and sales. About 60 percent of the sector's purchases originated in Florida in 1976, as indicated by the data in table B–7. This amounted to an expenditure in Florida of $14,615,100. The relative impact of the industrial chemicals sector on Florida is about the same as that of the phosphatic fertilizers sector but is considerably less than that of the mining sector.

The major Florida purchases of the industrial chemicals sector were electrical services, phosphate rock, and labor. These three categories alone amounted to about 90 percent of all the sector's purchases from Florida. The industrial chemicals sector is the most energy-intensive of the three sectors, because of its use of electric furnaces in the manufacture of elemental phosphorus. Inputs this sector obtains from outside the State include petroleum products, coke, and silica.

Distribution of Sales

MINING SECTOR

Estimates of the distribution of mining sector sales by Florida firms are given in table B–8 for 1976. About 52 percent of the 35,834,000 metric tons of phosphate rock sold from Florida plants was used within the State in the production of

Table B–8.—Estimates of the distribution of sales by the mining sector of the Florida phosphate complex, 1976 [1]

Market	Quantity sold, thousand metric tons	Percent of total
Fetilizer chemicals sector:		
Florida	18,404	52
Rest of United States	8,807	25
Industrial chemicals sector: [2] Florida	([3])	([4])
Exports	8,275	23
Total	35,800	100

[1] Based on data obtained from a Bureau of Mines survey; interviews by Florida State University personnel; the Ports of Jacksonville, Tampa, and Boca Grande; and the Florida Phosphate Council.

[2] Data for the rest of the United States were not available for this sector.

[3] Less than 500,000 metric tons.

[4] Less than 1 percent.

Table B–9.—Estimates of the distribution of sales by the fertilizer and industrial chemicals sectors of the Florida phosphate complex, by product line, 1976

Product	Quantity sold, thousand metric tons
Domestic sales (Florida and United States):	
Sulfuric acid	223.2
Phosphoric acid	987.0
Superphosphates and other fertilizer materials	[1]772
Phosphorus	NA
Export sales:	
Sulfuric acid	0
Phosphoric acid	395.0
Superphosphates and other fertilizer materials	[1]2,819.8
Phosphorus	.3

NA Not available.
[1] Exports and domestic shipments of superphosphates and other fertilizer materials exceeded Florida production by 601,000 metric tons. This reflected a drawdown of inventories and may have also resulted in part from differences in data classification.

Sources: U.S. Department of Commerce, Bureau of the Census; and Port Authorities of Tampa, Boca Grande, and Jacksonville.

fertilizer chemicals. About 25 percent of this total went to other States for further processing, and about 23 percent was exported. A very small portion of the mining sector's output was used in the production of industrial chemicals. The percentages shown in table B–8 reflect tonnages sold and not the value of sales. Since export prices are considerably higher than the domestic price of phosphate rock, a distribution according to sales value would be significantly different than the distribution shown in this table.

The largest importers of Florida phosphate rock are Belgium, Brazil, Canada, Japan, Iran, the Republic of Korea, Mexico, and the Netherlands. In addition, France, India, and Poland import significant amounts of Florida rock. Most of Florida's exported phosphate rock tonnage is shipped from the Port of Tampa.

FERTILIZER AND INDUSTRIAL CHEMICALS SECTORS

The preponderance of sales by these sectors are sales of agricultural chemicals. Most of the fertilizer chemicals are sold for export. In 1976 nearly 2,820,000 million metric tons of superphosphates and other fertilizer materials were exported (table B–9). Brazil, France, India, Italy, and Poland are all major importers of Florida fertilizer chemicals.

Phosphoric acid is the primary product sold domestically by the Florida fertilizer and industrial chemicals sectors. It is used in both agricultural and industrial activities. The two sectors' sales of phosphoric acid in 1976 amounted to 987,017 metric tons. Large tonnages of both phosphoric and sulfuric acid are produced and used internally in the Florida phosphate complex and are therefore not included in table B–9, which shows only interfirm sales. A major portion of the 223,168 metric tons of sulfuric acid sold in the United States in 1976 represented byproduct sales by Florida plants primarily engaged in phosphoric acid production.

APPENDIX C.—AGRICULTURAL FORWARD LINKAGE[1]

Precise knowledge of the total value of agricultural products which can be attributed to phosphatic fertilizer use requires information on the contribution of the fertilizer input with all other inputs held constant. This information is needed at two stages of production: (a) farm receipts and (b) retail outlet receipts.

We attempted to solve this problem in the following way. First, through the use of production function theory in conjunction with a very large sample of experimental data, we estimated the marginal contribution of phosphatic fertilizer to the value of four important crops. Although the experimental data are more than 10 years old (D. B. Ibach and J. R. Adams, 1968), the crop yield functions developed from the data gave yield results for 1976 that were in the most important case close to actual 1976 farm-gate prices of the four major crops in order to obtain estimates of additional value added to the product.

Crop yield estimates were developed for major crops in each state by parts of the 99 agricultural subregions (ASR's) in the United States for 1964 (D. B. Ibach and J. R. Adams, 1968). The yield curves indicate yields at different rates of application of the nutrient to which the yield response is greatest, usually nitrogen. However, the yield curve could be reestimated in terms of the yield response of phosphorus because the applications of each nutrient were not at fixed ratios.

The following method is used. The estimated yield function (in terms of nitrogen) is

$$Y = M - AR^x, \tag{1}$$

where Y = bushels per acre; M = maximum potential yield, A = the coefficient of R^x, R^x = the exponential yield function. Given an initial sample value of R^x, say R^x1, successive values of R^x are derived by multiplying R^x1 by the relative fertilizer application rates; i.e.,

$$\frac{N + P + K \text{ in selected application}}{N + P + K \text{ in initial application}}. \tag{2}$$

The amount of P (phosphorus oxide) per unit of $x(Q_p)$ is

$$Q_{p,i} = \frac{\overset{n}{\underset{i=1}{\cdot}}\, p}{x_i}, \tag{3}$$

where the quantity of phosphate applied in each sample is summed across all samples and x = exponent in yield function at the observation in question. Therefore, Q_p is the amount of phosphate per unit of the yield exponent. The value of $Q_{p,i}$ can be viewed as the marginal input of phosphorus at the ith observation. The value of the yield (Y) at the immediately preceding observation minus the yield at the ith observation is the marginal yield. The ratio of the marginal yield (ΔY_i) to the marginal phosphorus application ($Q_{p,i}$) is the marginal product of phosphorus application at the ith observation, or

$$MP_{pi} = \frac{\Delta Y_i}{Q_{p,i}}. \tag{4}$$

[1]Chapter from reference 6.

The average product can be found by the following formula:

$$AP_{pi} = \frac{Y_i}{Q_{p,i} \cdot x_i} \tag{5}$$

for the ith observation.

Six crops account for about 82% of the U.S. agricultural consumption of phosphatic fertilizer. They are grain corn, wheat, cotton, soybeans, hay and pasture, oats, and barley. Fertilizer application data are available only on corn, wheat, cotton, and soybeans. Applications of phosphate on these four major crops accounted for 62% of total phosphatic fertilizer used in agriculture in 1976.

Yield functions with respect to phosphorus for corn, wheat, cotton, and soybeans were estimated for the leading producing states from all ASR's in these states: Iowa corn, Kansas wheat, Texas upland cotton, and Illinois soybeans. Average and marginal products were calculated as described above. It was found that 1976 phosphorus application rates placed production near the peak of the 1964 yield curves for each crop. Therefore, only marginal products were used to calculate production values.

The following assumptions are invoked:

(1) The slope of the 1976 yield curves approximate those of 1964;

(2) As the greatest production of each crop takes place in the selected state, it is assumed that the yield curve slope applies to all harvested lands;

(3) Farmers received the average price on each crop in 1976.

The farm-gate value of that part of each crop that could be attributed to phosphatic fertilizer application was calculated as follows:

$$\begin{matrix}\text{Phos-}\\\text{phorus}\\\text{value of}\\\text{crop}\end{matrix} = \begin{matrix}\text{Total}\\\text{acres}\\\text{receiving}\\P_2O_5\end{matrix} \times \begin{matrix}\text{Average}\\P_2O_5\text{ ap-}\\\text{plication}\end{matrix} \times \begin{matrix}\text{Marginal}\\\text{product}\\P_2O_5\end{matrix} \times \begin{matrix}\text{Average}\\\text{crop}\\\text{price,}\\1976\end{matrix}$$

The values used appear in table C-1; and the estimated 1976 total crop values related to phosphate fertilizer appear in table C-2. Some $1.8 billion of agricultural crop value can be directly traced to the use of phosphatic fertilizers in 1976.

By far the greatest share of the total value is found in applications to the corn crop: some 65% of the value of the four crops is found in corn yields and some 22% in wheat yields.

How accurate are estimates derived from 1964 yield data? The data base, while dated, is very rich in the sense that a

Table C–1.—Estimated marginal products, phosphatic fertilizer application rates, and average crop prices, 1976

Crop	Marginal product per acre, bushels	P_2O_5 application rate, pounds	Average price
Corn	0.112	66.7	$2.49
All wheat	.107	37.2	3.14
Cotton (upland)	[1]1.22	52.1	.575
Soybeans	.003	42.3	5.58

[1] Pounds.

Table C–2.—Estimated crop value attributed to the use of phosphatic fertilizer, 1972

Crop	Values	Percent of total
Corn	$1,189,945,636	65
Wheat	406,140,058	22
Cotton	220,624,569	12
Soybeans	9,847,237	1
Total	1,826,557,500	100

large number of observations were amassed over very diverse soil and weather conditions in each state. However, it is possible that either the yield curves have since shifted up or down and/or the slope of the yield curves changed. Parallel shifts in the yield curves would not alter our marginal product findings.

The accuracy of the results can be assessed by comparing predicted 1976 yields from the 1964 yield curve with actual 1976 yields. This comparison is presented in table C-3. For the most important crop, grain corn, the yields are almost identical. The yields for soybeans are not greatly divergent. However, the yield differences for wheat and cotton (upland) are substantial. We believe that the wheat yield curve shifted downward in 1976, leaving marginal products (in terms of phosphorus application) relatively unchanged. The average wheat yield in 1964 is close to the 1976 average yield. In the case of cotton it is possible that the yield-curve slope has changed in addition to the yield curve shifting upward; we cannot be certain.

If all of the increase in the 1976 cotton yield compared with 1964 is a result of an increase in marginal products unassociated with phosphorus, the total phosphorus value of the crop should be reduced by $109,429,780, which is 6% of the estimated total value of the four crops.

Recall that the total value of $1.8 billion underestimates production due to phosphatic fertilizers since the four crops considered account for only 62% of total phosphatic fertilizer used in agriculture in 1976. This is true provided that the marginal physical product of phosphatic fertilizers related to the excluded crops is positive.

The estimated crops value of phosphatic fertilizer is only the "first round" impact from its application. Corn, wheat, and soybeans are further processed into food for both human and farm animal consumption. In turn, beef cattle, dairy cows, pigs, and poultry are consumed by persons at the retail level. Cotton is processed as fiber into cloth which is used to produce clothing.

Of the four crops, the most important in initial value (as we see in table C-2) is grain corn. We are able to trace the phosphorus-related value of corn all the way to the meat

Table C–3.—Comparison of predicted and actual crop yields, 1976

Crop	Yield predicted at 1976 P_2O_5 application rate, bushels	Actual 1976 yield, bushels	Percent of predicted yield actually realized
Grain corn	94.5	87.4	92.5
All wheat	49.4	30.3	61.3
Cotton (upland)	[1]310.2	[1]464.0	149.6
Soybeans	36.4	25.6	70.3

[1] Pounds.

Table C–4.—Uses of corn as final product, 1975–76

Product	Thousand bushels	Percent of total
Animal feed	3,558,400	87.8
Direct food	400,800	9.9
Alcoholic beverages	71,100	1.8
Seed	19,100	.5
Total	4,049,400	100.0

Table C–5.—Estimated value added by phosphatic fertilizers to dairy and meat products, 1976

Product	Value added
Beef	$601,251,800
Pork	313,288,190
Milk	12,825,034
Broilers and turkeys	734,771
Total	928,099,795

Table C–6.—Total estimated Phosphorus-produced retail value of major related final products, 1976

Product	Phosphorus-produced value
Crops	$1,826,557,500
Dairy and meat products	928,099,795
Cotton clothing	211,799,560
Total	2,966,456,855

market in the grocery store. The mark-ups on cotton are very straightforward, and we are able to derive a retail value for phosphorus-related cotton output. However, wheat and soybeans are more difficult to trace than even corn. Of these, soybeans are relatively unimportant in magnitude and wheat is much less significant than corn. In any case, given time and budget constraints we are unable to supply the retail values of phosphorus-related wheat and soybeans output.

The final product use of corn is varied. Its uses in the 1975–76 market year are detailed in table C-4. By far, corn's greatest value is indirect, through the feeding of livestock and poultry that later is processed as human food. Nearly 90% of corn is used for this purpose. Therefore, we will estimate its value as beef, pork, poultry, and milk.

During the 1975–76 market year corn was fed to animals as either a concentrate or directly as field corn. We applied the following procedure to the valuation of corn-fed beef, dairy cows (for milk), and poultry:

(1) All grain corn concentrate was converted to bushels of corn;

(2) The amount of corn per pound of animal was estimated;

(3) The total pounds of meat (or milk) attributable to the phosphorus-related amount of corn was computed;

(4) The meat (or milk) poundage related to phosphorus was multiplied by the average retail price of the meat or milk. The values are reported in table C-5. It is emphasized that this is a very rough estimate of these values.

Raw cotton fiber was marked up by 48% at the textile mill in 1976. If we further assume that wholesale and retail mark-ups total 100% for cotton clothing, the value-added or the final product related to phosphorus is $211,799,560.

These estimated values are summed in table C-6. The total product value is nearly $3 billion.

APPENDIX D.—A REGIONAL ECONOMIC IMPACT SCENARIO OF ASSUMED DECLINES IN MINERAL PRODUCTION FOR THE PHOSPHATE ROCK MINING INDUSTRY IN FLORIDA

Background

The U.S. phosphate industry is presently stable, as is the position of U.S. phosphate rock and its derivative products in world markets. A review of U.S. phosphate rock mining and processing with respect to regional economic impact suggests that the continued viability of the phosphate industry in Florida will be influenced by the existing industry conditions listed below. These conditions are the basis for the scenario which is presented later in this appendix.

1. The United States currently mines and processes 40 percent of the world's phosphate rock.
2. The State of Florida in 1978 accounted for 80 percent of the U.S. production of phosphate rock.
3. Florida produced about one-third of the world supply of phosphate rock in 1978.
4. The real costs of new investment capital for the phosphate industry have been increasing by 6 percent per year, while the real prices of phosphate-related products have been falling since 1975.
5. Florida's high-quality reserves in Polk and Hillsborough Counties are being depleted and are expected to be largely exhausted by the end of the century.
6. Environmental regulations and competition for water and energy in the central Florida mining region have not encouraged new mine development.
7. Technologically oriented productivity increases are lagging, i.e., there is a lack of new technology for concentrating low-quality, high-impurity phosphate ore deposits.
8. The present transportation system for handling phosphate rock and related products between the central Florida region and the Port of Tampa appears to be adequate, but with future increases in output, it is expected that this transportation system will become a restricting factor.
9. Phosphate rock and derivative products are internationally traded commodities. The competitive position of Florida resources may decline as higher cost mines replace older, depleted low-cost mines. This could possibly limit the incentive to expand Florida's phosphate rock mining capacity.

Based upon these conditions, and an assumption of declining production, the scenario which follows is intended as a projection of the economic profile of the Florida phosphate industry for 1990. Currently, approximately 20 phosphate rock mines are operating in Florida, producing approximately 40 million metric tons of rock per year. It is assumed in the scenario that Florida production of phosphate rock will reach a peak in 1985, and maintain the peak level until roughly 1987, and decline thereafter. The scenario considers the effects of a decline in output from 1987 to 1990, but the year 1990 is highlighted.

METHODOLOGY

After the factors which may restrict growth are identified, a scenario is suggested that could represent the market situation in 1990. From this scenario, a likely set of employment, income, and fiscal impacts are identified. These impacts are based on an interindustry input-output (I-O) table adapted for the State of Florida (*17*). From the I-O table, a set of type I and type II income and employment multipliers were derived, along with a multiplier that identifies the magnitude of changes in both direct and indirect output (*19*).

The output multipliers for the phosphate industry measure the sum of direct and indirect requirements from all sectors needed to deliver one additional dollar of phosphate industry output to final demand (consumers). These multipliers were derived by summing the entries in the column of phosphate industry data in the Leontief inverse matrix table,[1] which showed the direct and indirect requirements per unit (one dollar) of final demand for each sector.

The type I income multiplier expresses the ratio of the direct plus the indirect income change to the direct income change resulting from a unit increase in final demand for the phosphate industry. While the type II multiplier is the ratio of the direct, indirect and induced income change due to a unit increase in final demand. The type II multiplier takes into account the repercussionary effects of secondary rounds of consumer spending in addition to the direct and indirect interindustry effects.

The employment multiplier is analogous to the type I income multiplier and is the ratio of the direct plus indirect employment change to the direct employment change. Similarly, the employment multiplier is parallel to the type II income multiplier, it measures the ratio of the direct, indirect and induced employment change to the direct employment change.

The fiscal impact on the state for 1990 was based on tax rates for years that information was readily available and valued in 1977 dollars.

Assumptions

The following assumptions were made for calculation purposes:

1. The market price of phosphate rock is expected to reflect the real costs of new investment capital, production cost, and inflation. From a supplier's point of view, a higher selling price is justified when there is an increase in the cost of production. On the demand side (from the consumer's point of view), a price increase is acceptable only when there is a real shortage of phosphate rock. For example, if the demand for phosphate rock is greater than the quantity supplied, a price increase is justified in order to allocate resources efficiently.
2. The proportion of phosphate rock equivalent available for export is a function of the level of domestic production and domestic price, foreign demand, and relative international price.
3. Technology and productivity are expected to be generally stable for the next decade. No radical breakthroughs in technology or significant increases in productivity are anticipated. The assumption is made that any technological innovation that would increase productivity in the next decade will be offset as the richer ores are depleted and ores of lower grade with more impurities are mined.

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[1] The Leontief inverse matrix table was derived from a direct requirements I-O table prepared for the State of Florida.

4. The present number of employees per million tons of output, as factor inputs, will approximate the employment utilization rate for the 1981–90 decade.

5. The reserve position of phosphate rock will vary directly with the inflation-adjusted price and any changes in technology that take place in the next 10 years.

6. The transportation system that exists in Florida at the present time—mainly the railroad and trucking system—is typical of the system that will exist there in 1990.

7. As a result of inflation and increasing costs, the valuation of phosphate rock for State severence tax purposes (which is based on operating costs) is expected to increase. An increase in this tax would be viewed by the industry as a cost and would be passed on to the consumer in the form of higher prices.

Analytical Strengths and Weaknesses

The strength of the type of analysis used in this scenario is its usefulness in identifying the factors that must be considered in order to approximate future conditions based on existing identified trends. The shortcoming of this type of analysis, however, is its assumption that all relevant factors, other than those for which changes are stipulated, will remain unaltered. In all likelihood, even if the predictions of this scenario hold up, the pricing structure of the market will be altered in response to changes in supply.

Scenario for 1990

In this scenario, probable economic conditions are assumed which could by the end of this decade inhibit the long-term growth that has been characteristic of the Florida phosphate industry. Specifically, it is the growth of the industry's new and replacement productive capacity that is expected to be limited by future economic constraints, according to this scenario. Consequently, the scenario assumes that production by the Florida phosphate industry will be declining by the end of the decade.

The scenario describes the projected regional impact that the assumed decline in production would have on the State of Florida and also projects the value of the lost output (phosphate rock and fertilizer products) that would result. The probable employment, income, and fiscal impacts that capacity reductions would have for the year 1990 are also analyzed.

ASSUMED LIMITS TO GROWTH

The assumed limits to the industry's capacity growth have to do with the price of phosphate rock, capital costs, ore extraction considerations, government regulation, and the adequacy of transportation between the Florida phosphate district and the Port of Tampa. In addition to these constraints, lags in capacity growth are also expected to result from the depletion of reserves in operating mines.

Price

Probably the most important of the assumed limits to capacity growth will be the price of phosphate rock. At the present time, it appears that the price of phosphate rock is stable, but all indications suggest that the price will increase in the future. If the price does increase, it is likely that this would weaken the competitive position of Florida and other U.S. phosphate rock in the world market.

Capital Costs

It has been estimated by the Bureau that real capital costs of the phosphate industry are increasing by 6 percent a year. If the market price of phosphate rock does not keep pace with escalating capital costs, investment will likely be discouraged.

Ore Extraction Considerations

The location and quality of phosphate ore are major factors in evaluating the costs of extraction. Compared with previously mined deposits, some new deposits have deeper overburdens, thicker matrices, lower pebble-to-feed ratios, lower grade ore compositions, and higher levels of impurities. It is expected that these factors will result in increased production costs and delays in development.

Further delays and additional costs are expected to arise from the development of commensurate technology for handling the ore bodies. Through new technology it may be possible to extract more phosphate from the matrix, but this technology has yet to be developed.

Government Regulation

The Florida phosphate industry is under the authority of numerous Federal, State, county, and district agencies and regulations. Regulation by these agencies can result in economic impacts for the industry. In the next decade, environmental regulations, in particular, may lead to economic impacts, both in terms of delays in development of new mines and increased costs. These delays and cost increases may in turn adversely affect expansion of the industry's productive capacity, either directly or indirectly.

From 5 to 7 years may elapse between the time a firm decides to mine at a specific location and the time that approval for mining is received. The process leading to approval to mine begins with a Development of Regional Impact (DRI) application. This is a document prepared by the mining company that details proposed construction, mining, and plant operations. The DRI application details the impact of the proposed mining on housing, roads, water resources, air quality, etc. It is reviewed by local, regional, and State bodies. If the DRI is approved, the company may then apply for mining permits from the regulatory agencies. A list of agencies from which permits must be obtained is provided in table D–1.

After approval of a DRI, each mining operation is subject to regulation by Federal agencies, including the Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA), Mining Enforcement and Safety Administration (MESA), and the U.S. Geological Survey (USGS). In addition, phosphate operations in Polk and Hillsborough Counties are subject to the authority of the following State, county, and district agencies and regulations:

1. Florida Department of Natural Resources
2. County Protective Development Regulation
3. County Lime Rock Mining Ordinance
4. County Zoning Ordinance
5. County Building Code
6. County Health Department
7. County Environmental Protection Act
8. Southwest Florida Water Management District

TABLE D–1.—Mining and processing permits and approvals

Permit[1]	Agency
FEDERAL	
Ambient Air Quality (CAA)	U.S. Environmental Protection Agency.
Emission Standards (CAA)	Do.
Pre-Construction Review and Approval (CAA)	Do.
Water Quality (CWA, NPDES)	Do.
Dredge and Fill permit (NPDES)	U.S. Army Corps of Engineers.
Environmental Impact Statement (NEPA)	Council of Environmental Quality and responsible agency.
STATE	
Development of Regional Impact	Division of State Planning (through Regional Planning Council).
Air Quality (FAWPCA):	Department of Environmental Regulation.
Permits to construct	Do.
Permits to operate	Do.
Permits to maintain	Do.
Permits to expand	Do.
Permits to modify	Do.
Water Quality (FAWPCA):	Do.
Industrial Waste Water	Do.
Dredge and fill	Do.
Drainage well permit	Do.
Potable Water Supplies (FSDWA)	Do.
Dam Construction	Do.
Construction of Wells	Water Management District.
Consumption Water Use	Do.
Works of the District	Do.
Management and Storage of Surface Waters	Do.
Licensing of Radioactive Material	Department of Health and Rehabilitative Services.
Reclamation	Department of Natural Resources.
LOCAL	
Zoning	(County government).
Operating (Mining Ordinance)	Do.
Master Plan approval	Do.
Development Order	Do.
Building permit	Do.
Pollution Control	Do.
Well Drilling	Do.

[1] Abbreviations shown in this column are identified as follows: Federal: CAA, Clean Air Act; CWA-NPDES, Clean Water Act-National Pollutant Discharge Elimination System; NEPA, National Environmental Policy Act; State: FAWPCA, Florida Air and Water Pollution Control Act; FSWDA, Florida Safe Drinking Water Act.

9. Florida Department of Environmental Regulation As mining progresses into other counties, similar ordinances, codes, and regulations may also be adopted by those counties.

Transportation

Another possible constraint on capacity growth is the uncertainty of the continued development of an adequate transportation system for phosphate rock and related products. The rail and truck transportation corridor between the central Florida phosphate district and the Port of Tampa is presently operating near capacity.

The major portion of the total rail traffic in the corridor is comprised of trains carrying phosphate rock, phosphate products, and/or related products. Rail is the primary mode for high-volume movements of dry phosphate rock from beneficiation plants to shipping ports and from beneficiation plants to chemical plants (*7*). In 1977 rail traffic in the corridor handled more than 14 million short tons of phosphate products for international trade and another 9 million short tons for the domestic market. The volume of phosphate and other rail traffic is so large, however, that it significantly contributes to motor vehicle traffic congestion. The railroad crosses a major highway at least three times on its route from the mining district to the Port of Tampa. As a result, trains crossing the highway cause motor vehicle traffic congestion at any time of day, 7 days a week. There are as many as 10 trains daily, and each causes a 15-minute delay, so there can be delays totaling 2½ hours each day at each crossing.

Table D–2.—Estimated tonnage of truck shipments between Tampa and phosphate plants, 1977.

Product	Total shipments, short tons	Loads per day
Tampa to phosphate plants:		
Fuel oils, Nos. 5 and 6	[1]4,400,000	120
Sulfur, molten	3,500,000	450
Ammonia, anhydrous	165,000	32
Caustic soda	145,000	20
Diesel fuels	NA	NA
Phosphate rock plants to Tampa:		
Phosphate rock	2,000,000	260
Triple superphosphate and diammonium phosphate	1,400,000	148
Phosphoric acid	825,000	110
Defluorinated phosphate	187,000	27

NA Not available.
[1] Barrels.

Trucks also use this transportation corridor to haul phosphate rock and related products. In 1977 the trucking industry hauled approximately 2 million short tons of phosphate rock to the Port of Tampa, as shown in table D–2. The same trucks took back to the phosphate district 3.5 million short tons of liquid sulfur; 4.4 million short tons (combined) of diesel fuel, fuel oil for flotation, gasoline, and kerosene; and other items (*6*).[2]

ASSUMPTION OF DECLINING PRODUCTION

The assumption is made in this scenario that phosphate rock production in Florida will increase from 40 million metric tons in 1979 to approximately 55 million metric tons per year in the 1985–87 period. Expansion of existing mines and planned new mines are expected to account for the increase. However, it is further assumed that production will decline after 1987, falling off to 47 million metric tons in 1990. At the present time, only a few companies are known to be planning the introduction of replacement capacity to offset this anticipated decline in production. This means that a net reduction in output of approximately 8.8 million metric tons can be expected between 1987 and 1990. This loss of output would amount to 16 percent of the projected annual production for the 1985–87 period.

EFFECTS OF DECLINING PRODUCTION

The impact of the previously described assumed bottlenecks to capacity expansion and utilization and the projected production decline of 8.8 million metric tons of phosphate rock between 1987 and 1990 is projected below for the year 1990. A capacity utilization rate of 90 percent is projected. It

[2]Also based on Tampa Port Authority data and other data.

is assumed that the decline in production will have a similar direct effect on the manufacturing of phosphate fertilizer and related products.

Direct and Indirect Output

Based on interindustry input-output multipliers that have been developed for the Bureau for regional impact use (*17, 36*) the following measurements of the Florida phosphate industry's direct and indirect output are expected in 1990 (with estimates given in million 1977 dollars):

	Mining benefication	Fertilizer manufacturing	Combined
Direct output[1]	196	209	[2] 405
Indirect output	116	162	277
Total	312	371	682

[1] Output is valued at 1977 prices and a weighted average of domestic and export product.
[2] Output has been adjusted for doublecounting of value added.

Based solely on these projections, it is projected that the industry's direct output (sales) will decline by approximately $405 million by 1990, on an annual basis. The total effect of the projected production decline, however, would be greater than $405 million. In addition to sales by the phosphate industry, sales of goods and services to the industry by its suppliers (or second-level effects) must also be included. In turn, third-level suppliers' sales (those necessitated by phosphate industry activity to second-level suppliers) must also be included. In addition to the output effect, further repercussions would be felt throughout the Florida economy. The total direct and indirect output loss during 1990 is esitmated to be $682 million. Furthermore, it is likely that a similar situation will exist in 1991.

Employment and Income

Employment and income would also be affected by a decline in phosphate production. An estimate of employment associated with the projected decline in production, as described above, has been calculated as follows for 1990:

	Number of jobs
Direct	[1]2,000
Indirect	1,800
Induced	4,000
Total	7,800

[1] The assumption is made that the employment effect would weigh equally on the mining and benefication and the fertilizer processing industries.

The total employment effect of the reduction in capacity would be the loss of approximately 7,800 jobs. Since the phosphate industry's employees are among the highest paid in the State, the loss of these jobs would result in a significant income loss. It is estimated that a total employment income of $74 million will be lost in 1990 due to restricted capacity growth of the Florida phosphate industry. This $74 million in projected lost income, which was previously included in the total output figure of $682 million, is broken down as follows, in million 1977 dollars:

Direct income	26
Indirect Income	19
Induced income	29
Total	74

Taxes

Along with the income effect, it is projected that a corresponding tax revenue or fiscal impact will be felt at all levels of Florida government. Based on the amount of 1976 property taxes paid by the phosphate industry, it is estimated that the State will lose approximately $6 million in property taxes from the industry in 1990. This tax loss and other projected tax losses for 1990 are shown below, in million 1977 dollars.

State property taxes	6.0
State corporate income tax	.6
State severence tax	10.0
Ad valorem county tax	.8
Total	17.4

The State corporate income tax loss is estimated to be $600,000, based on the State corporate income tax the industry paid in 1976. The loss in State severence tax is estimated at approximately $10.0 million—which is a very conservative estimate—based on the 1977 severence tax rate of $1.27 per metric ton.[3] The ad valorem county tax loss is estimated at $794,000, which is based on the approximate 1977–78 tax paid by the industry. It is estimated that the total loss of Florida tax revenues as a result of the projected decline in phosphate production will be $17.4 million for the year 1990 (*6, 22*).

Possible Benefits of Production Delays

A discussion of this scenario would not be complete without some mention of the possible beneficial effects that delays in phosphate rock production could have. Delays in production would provide technological innovation time for seeking solutions to the many problems involved in recovering larger quantities of lower grade phosphate from the matrix and possibly shortening the time required to reclaim land for other useful purposes. Production delays would also extend the life of reserves. In addition, some land that might otherwise be used for mining could possibly be released for other uses as a result of delays in production; these other uses might include agricultural, residential, commercial, or recreational uses.

SUMMARY AND CONCLUSIONS

It is assumed that the capacity growth of the Florida phosphate industry will be restricted by the end of this decade as a result of the depletion of high-grade reserves and also because of certain economic, environmental, regulatory, technological, and transportation constraints. As a result of this restricted growth, the following effects, relative to the Florida phosphate industry, are projected for the year 1990:[4]

[3] This severance tax rate was applied to 10 percent of the value of the phosphate rock at the point of severance. This tax applies only in Florida (*11*).

[4] All values are in 1977 dollars.

1. There will be a loss in direct output of 8.8 million metric tons of phosphate rock and 2.6 million metric tons of phosphate fertilizer with a combined value of $405 million. Together with a commensurate $277 million loss of output in secondary and tertiary industries, the total projected loss of output is $682 million.

2. The total employment effect, including direct, indirect, and induced employment, will be the loss of 7,800 jobs.

3. The income loss due to restricted capacity (which is included in the value of output described above) will total approximately $74 million.

4. It is estimated that the State of Florida will lose $17.4 million in tax revenues.

If the restrictions to capacity growth were to persist beyond 1990, the above effects would be expected to continue for successive years.

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